

# Abundance analysis of the supergiant stars HD 80057 and HD 80404 based on their UVES Spectra

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## Abstract

This study presents elemental abundances of the early A-type supergiant HD 80057 and the late A-type supergiant HD 80404. High resolution and high signal-to-noise ratio spectra published by the UVES Paranal Observatory Project (Bagnulo et al., 2003)<sup>1</sup> were analysed to compute their elemental abundances using ATLAS9 (Kurucz, 1993, 2005; Sbordone et al., 2004). In our analysis we assumed local thermodynamic equilibrium. The atmospheric parameters of HD 80057 used in this study are from Firnstein & Przybilla (2012), and that of HD 80404 are derived from spectral energy distribution, ionization equilibria of Cr I/II and Fe I/II, and the fits to the wings of Balmer lines and Paschen lines as  $T_{\text{eff}} = 7700 \pm 150$  K and  $\log g = 1.60 \pm 0.15$  (in cgs). The microturbulent velocities of HD 80057 and HD 80404 have been determined as  $4.3 \pm 0.1$  and  $2.2 \pm 0.7$  km s<sup>-1</sup>. The rotational velocities are  $15 \pm 1$  and  $7 \pm 2$  km s<sup>-1</sup> and their macroturbulence velocities are  $24 \pm 2$  and  $2 \pm 1$  km s<sup>-1</sup>. We have given the abundances of 27 ions of 20 elements for HD 80057 and 39 ions of 25 elements for HD 80404. The abundances are close to solar values, except for some elements (Na, Sc, Ti, V, Ba, and Sr). We have found the metallicities [M/H] for HD 80057 and HD 80404 as  $-0.15 \pm 0.24$  and  $-0.02 \pm 0.20$  dex, respectively. The evolutionary status of these stars are discussed and their

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<sup>1</sup>Based on data obtained with the UVES Paranal Observatory Project (ESO DDT Program ID 266.D-5655)

nitrogen-to-carbon ( $N/C$ ) and nitrogen-to-oxygen ( $N/O$ ) ratios show that they are in their blue supergiant phase before the red supergiant region.

*Keywords:*

Stars: abundances - Stars: individual: HD 80057 - Stars: individual: HD 80404 -

Techniques: spectroscopic

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## 1. Introduction

A-type supergiants are attractive astrophysical targets for chemical abundance studies. First of all, they are among the brightest stars at visual wavelengths, which makes them observable with low exposure times, high resolution and high signal-to-noise ratios (S/N). Moreover, their spectra are unblended, hence the abundances of numerous elements with consecutive ionization levels such as light elements,  $\alpha$  process elements, iron group and s-process elements can be derived from studies of their atmospheres (Venn, 1995; Albayrak, 2000; Przybilla, 2002; Schiller & Przybilla, 2008; Firnstein & Przybilla, 2012; Tanriverdi, 2013). With these results in hand, it is possible to understand their nature and the environments in which they exist, and thereby study galactic and extra-galactic abundance gradients and dispersions.

This paper is a continuation of analyses of early and late A-type supergiants started by Tanriverdi et al. (2004); Tanriverdi (2013). In this study, elemental abundance analyses of two A-type supergiants, HD 80057 and HD 80404 (*iota* Car), and their revised atmospheric parameters, are presented in detail. These analyses are based on spectra distributed by the UVES Paranal Observatory Project (Bagnulo et al., 2003).

### 1.1. HD 80057

HD 80057 (HR 3688, HIP 45481, SAO 221010) was classified as A1 Iab by (Firnstein & Przybilla, 2012) (see Table 1 for more information). It is a member of the Vela OB1 association of stars, which is one of the largest OB star associations of the Galaxy, and is composed of numerous members (Reed, 2000). Although HD 80057 has been used as a photometric

standard star, (Menzies et al., 1989; Cousins, 1990), and as a spectroscopic standard star for its radial velocities (Reed & Kuhna, 1997; Gontcharov, 2006), a detailed study of its atmosphere was published only very recently by Firnstein & Przybilla (2012). The authors determined the atmospheric parameters ( $T_{\text{eff}}$  and  $\log g$ ) using spectroscopic indicators and spectroscopic data (see Table 2) in their study, as well as CNO abundances of HD 80057 computed using non-LTE methods.

### 1.2. HD 80404

*iota* Car (HD 80404, HR 3699, HIP 45556, SAO 236808) is an MK Standard, which is classified as A8 Ib (Malaroda, 1973; Monier & Parthasarathy, 1999) (see Table 1 for more information). It is one of the brightest stars in the southern sky in the visual region of the electromagnetic spectrum. Adelman et al. (2000) listed it amongst the least variable Hipparcos targets, while Gray & Garrison (1989) gave its Strömgren photometric parameters.

The atmosphere of *iota* Car was first studied in detail by Boiarchuk & Liubimkov (1984), who gave its spectroscopic parameters as  $7300 \pm 200$  K for its effective temperature and  $1.40 \pm 0.2$  for its surface gravity. Luck & Lambert (1985) later gave elemental abundances for the star as well as revising its stellar parameters, finding  $T_{\text{eff}} = 7500 \pm 200$  K,  $\log g = 0.90 \pm 0.3$ , and micro & macro-turbulent velocities of 2.5, and  $1.0 \pm 0.5 \text{ km s}^{-1}$ , respectively. Next, Luck & Lambert (1992) adopted the effective temperature found by Luck & Lambert (1985) as 7500 K, and found a value of  $1.6 \pm 0.2$  for its surface gravity using the MARCS code of Gustafsson et al. (1975) from its Fe I/II ionization balance. Then, Takeda & Takada-Hidai (1995) re-calculated the CNO abundances of *iota* Car using Luck & Lambert (1985)’s atmospheric parameters and equivalent widths (EW).

Smiljanic et al. (2006), on the other hand, computed the effective temperature to be  $7500 \pm 200$  K, surface gravity  $2.40 \pm 0.25$ , and micro-turbulent velocity  $2.34 \pm 0.35 \text{ km s}^{-1}$  based on their high-resolution spectroscopic observations using fits to the  $\text{H}\alpha$

wings, the Fe I/II ionization equilibrium and their photometric calibration (see Table 2). They also determined its C, N, O, and Fe abundances from their FEROS (Fiber-fed Extended Range Optical Spectrograph) spectra in the wavelength range 3500-9200 Å and a resolution,  $R=48000$ . Later on, spectrophotometric observations (visual and near-infrared) of the object were presented by Ruban et al. (2006).

## 2. The Spectra

The UVES spectra used in this study were obtained from the UVES-POP database. They have high resolution ( $R \sim 80000$ ) and S/N ratios (for most of the spectra S/N ratio  $\sim 300$ -500 in V band). They cover a wavelength range of  $\lambda\lambda$  3040-10400 Å (Bagnulo et al., 2003)<sup>2</sup>. The ultraviolet (UV), visual and infrared (IR) parts of UVES spectra were used to determine the abundances of elements such as C, N, O, Mg and Al (see Table 3). All spectra were continuum normalized using *IRAF*<sup>3</sup> task *continuum*. Then, the EWs of the identified lines were measured using the *splot* package within IRAF. Main sources for line identification are mentioned in Tanriverdi (2013). International Ultraviolet Explorer (IUE)'s flux-calibrated spectra were downloaded from MAST<sup>4</sup> archive. For spectrophotometry of HD 80404, low-dispersion and large aperture spectra, *SWP36720* and *LWP15980*, were used.

## 3. Stellar Parameters

The atmospheric models were produced using ATLAS9 (Kurucz, 1993; Sbordone et al., 2004). LTE abundance analyses were performed based on EW measurements using the WIDTH9 code (Kurucz, 1993). The effective temperatures and surface gravities ( $T_{\text{eff}}$ ,

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<sup>2</sup><http://www.eso.org/sci/observing/tools/uvespop.html>

<sup>3</sup>IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy (AURA) under cooperative agreement with the National Science Foundation.

<sup>4</sup><http://archive.stsci.edu>

$\log g$ ) were determined via SED (Spectral Energy Distribution, see Fig. 1) analyses, fits to Balmer and Paschen lines wings (see Figs. 2 & 3) and from the ionization equilibria of Cr I/II and Fe I/II (see Fig. 4). The procedure used to determine these fundamental parameters are illustrated on the  $T_{\text{eff}} - \log g$  plane in Fig. 4. The microturbulent velocity was determined by finding the value where the correlation between the derived abundances and the EWs ( $\xi_1$ ) was minimised, and the minimum scatter about the abundance mean ( $\xi_2$ ) was obtained (Blackwell et al., 1982). Microturbulent velocities were determined for HD 80057 and HD 80404 to be  $4.30$  and  $2.20 \text{ km s}^{-1}$ , respectively. The derived microturbulent velocities of different species are given in Table 4. The rotational velocity and the macroturbulent velocity of HD 80057 are determined using synthetic spectra produced by SYNSPEC and SYNPL0T (Hubeny, 1988; Hubeny & Lanz, 2011). The rotational and macroturbulence velocities for HD 80057 are  $15 \pm 1 \text{ km s}^{-1}$  and  $24 \pm 2 \text{ km s}^{-1}$  and those for HD 80404 are  $7 \pm 2 \text{ km s}^{-1}$  and  $2 \pm 1 \text{ km s}^{-1}$ .

The SED in Fig. 1 was reproduced using ATLAS9 flux models. The spectrophotometric data were obtained from Ruban et al. (2006). The photometric data, angular diameter and  $E(B-V)$  are given in Table 1. The zero-points reported by Heber et al. (2002) were used to transform the various magnitudes into monochromatic fluxes. It was assumed that  $y = V$  to transform  $b-y$ ,  $c_1$  and  $m_1$  indexes to  $u$ ,  $v$ ,  $b$  and  $y$  magnitudes. The computed fluxes of HD 80404 ( $T_{\text{eff}} = 7700 \text{ K}$  and  $\log g = 1.60$ ) were also consistent with its SED. The synthetic spectrum was reproduced for  $H_\delta$  increasing and decreasing  $\pm 150 \text{ K}$  or  $\pm 0.15 \text{ dex}$ ,  $T_{\text{eff}}$ , and  $\log g$ , respectively using SYNTHE (Kurucz & Avrett, 1981). We also used the bluest part of the Balmer series. Different to the synthetic Balmer series spectrum, we also tried to determine the  $T_{\text{eff}}$ ,  $\log g$  pair of the Paschen series, for which we obtained a good fit. Paschen lines were previously used by Schiller & Przybilla (2008) to determine the atmospheric parameters of Deneb. The excitation potentials of Fe I and Fe II lines in our abundance analysis ranged from  $0.00 \text{ eV}$  to  $10 \text{ eV}$ . Their abundances and excitation potentials showed no correlation at  $T_{\text{eff}} =$

7700 K (see Fig. 5). The slope of the excitation potential to Fe abundances was  $-4.943 \times 10^{-3} \pm 3.764 \times 10^{-3} \text{ dex}^{-1}$ . This is another method to determine the atmospheric parameters, such as  $T_{\text{eff}}$ . Moreover, the ionization equilibrium is also good tool to determine the stellar parameters. Ionization equilibrium for the consecutive ionization stages of Cr I/II and Fe I/II were fulfilled in the atmospheres of HD 80404. The errors in the determined values of  $T_{\text{eff}}$  and  $\log g$  were assumed to be  $\pm 150 \text{ K}$  and  $\pm 0.15 \text{ dex}$ , as determined from their  $H\delta$  fits, and the error of the microturbulent velocity value was assumed to be  $0.7 \text{ km s}^{-1}$ , as obtained from microturbulence velocity determinations of individual elements in Table 4.

#### 4. The results of the abundance analysis

The elemental abundances found in this study for HD 80057 and HD 80404 are presented in Table 3 and Fig. 6, together with a comparison of our results with solar composition and previous studies. The systematic error calculated for the abundances of HD 80404 are given in Table 5. The detailed abundances are given in Table 6, which also includes the elements used in the analysis, the wavelengths of the identified lines, gf values, and their references. The ionization equilibrium of different elements/ions for target stars are seen in Table 3.

While the errors in  $T_{\text{eff}}$  have the strongest effect on the abundances of Mg II, Al I, Fe I and Ba II, the error in  $\log g$  affects most strongly those of Mg II, S II, Ca I and Ca II. This might be due to the fact that these species have the strongest lines with the large EWs.

The sum of CNO abundances of both stars have a solar value. For HD 80057,  $\alpha$ -process elements, except for Si and Ca, are also under-abundant. Al, Sc, Ti, and V are found to be under-abundant. However, Cr, Mn, Fe, and Ni abundances are found to be closer to solar values. Sc, Ti, and V are susceptible to non-LTE effects, which can be ascribed to the value of their second ionization potentials. These are the lowest second

ionisation potential in the Iron Group (Przybilla, 2002). The heavy elements (Sr, Y, Zr, Ba) are also underabundant with respect to solar abundances.

In the atmospheres of HD 80404;  $\alpha$ -process elements (Si, S and Ca) and the light element Al are closer to solar values, Mg is deficient, however Na is overabundant. Sc, Ti, V, Cr, Mn, Fe, Co and Ni are all closer to solar values in the atmosphere of HD 80404. The heavy elements tend to have values slightly smaller than solar, Ba is overabundant (see Fig. 1).

## 5. Results and Discussion

As a result, the  $[M/H]$  ratio of HD 80057 is found to be  $-0.15 \pm 0.24$  dex when we exclude the over-abundant Na due to NLTE effects (Takeda & Takada-Hidai, 1994; Venn, 1995; Takeda, 2008), the under-abundant Sc and Ti, which are all susceptible to non-LTE effects. The  $[M/H]$  ratio of HD 80404 is estimated to be  $-0.02 \pm 0.20$  dex when we exclude the over-abundant Na element. The  $N/C$ ,  $N/O$  and  $\Sigma CNO$  values are given in Table 7.

### 5.1. Evolutionary Status

Light-element, the sum of  $CNO$  composition reflects mixing process present in the interior of the star. Both stars show a deficiency of C and O, and an enrichment of N. Hence, the combined  $CNO$  abundances were found to be close to the solar value (see Table 7). Both stars also have solar metallicity. The values of  $N/C$  and  $N/O$  predicted from a linear interpolation of the closest isochrones are consistent with their calculated values (see Table 7). The  $N/O$  ratio of HD 80057 is found to be slightly smaller than the theoretical value 0.52.

The early CNO contamination in the surface layers of stars can be explained by rotating models. Rotation is an essential factor of stellar models that have a profound effect on the evolution of especially massive stars. Red giants or supergiants, whose progenitor is fast rotating progenitors, rotate six times faster and show  $N/C$  ratios three

time higher than those formed by slow rotators (Przybilla et al., 2010; Georgy et al., 2013; Maeder et al., 2014). Georgy et al. (2013) provide extended data of stellar models including the mass range from 1.7 to 15  $M_{\odot}$  with three different metallicities and with nine different initial rotation velocity models. In the framework of their study, one can see that C, N, and O abundances varies with different initial rotating models. So, we take into account, initial rotational velocities,  $N/C$  and  $N/O$  ratios, besides  $T_{\text{eff}}$  and  $\log g$  in stellar evolution models.

In order to investigate the evolutionary states of our targets, we used the Geneva Stellar Model (Georgy et al., 2013) interactive tools<sup>5</sup> to interpolate between the existing evolutionary tracks that would lead to models with parameters matching those of our targets. We used the relevant parameters ( $\log T_{\text{eff}}$  and  $\log g$ ) from Firnstein & Przybilla (2012) for HD 80057 and our own measurements for HD 80404.

We experimented by interpolating models for different masses of grids that covered a wide range of masses between 1.7 and 15  $M_{\odot}$ . We kept the metallicity at solar composition ( $Z = 0.014$ ), and the rotation rate at  $v / v_{\text{crit}} = 0.0$  to 0.95 in each case.

We searched for the probable evolutionary track, which would be the one with the closest agreement with the atmospheric parameters of our stars (e.g. effective temperatures and surface gravities). We found that both of our stars have masses between 10  $M_{\odot}$  and 14  $M_{\odot}$ . While HD 80057 has a mass consistent with the track for 13  $M_{\odot}$ , HD 80404 is very close to the track for 12  $M_{\odot}$ . The latter result is based on its fundamental parameters (Fig. 7), which assumes solar composition and rotation with values of  $\Omega / \Omega_{\text{crit}} = 0.60, 0.50$  (see Table 7). These gave globally good fit to stars from the main-sequence to the positions of the blue supergiants before the red supergiant phase in the Hertzsprung-Russell Diagram (hereafter HRD) (Georgy et al., 2013).

On the  $\log T_{\text{eff}} - \log g$  plane, we also computed isochrones using the same online tools and selected the ones to which our stars' parameters had the closest matches

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<sup>5</sup><http://obswww.unige.ch/Recherche/evoldb/index/>



(Fig. 8). Our results indicate ages close to 16 Myrs for HD 80057 and 19 Myrs for HD 80404. When the errors in the measurements of the parameters, expressed as the error bars in Fig. 8, were considered, a good estimate was obtained for ages between 12.5 and 25 Myrs for both of our stars. The abundance ratios  $N/C$  that we computed in this study (2.45 for HD 80057 and 1.57 for HD 80404) are somewhat consistent (within the uncertainty limits) with the stars' positions on the  $\log T_{\text{eff}} - \log g$  plane, for which the expected  $N/C$  ratios are printed next to each of the isochrones in Fig.8. The derived values of the  $N/C$  and  $N/O$  ratios from the isochrones are given in Table 7. These ratios reveal that  $CNO$  mixing processes are active, and that these stars are at the Blue Supergiant (BSG) phase in their evolution prior to the Red Supergiant (RSG) phase, as according to Saio et al. (2013).

## 6. Acknowledgements

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Wiese, W. L., & Fuhr, J. R. 2007. J. Phys. Chem. Ref. Data 36, 1287.

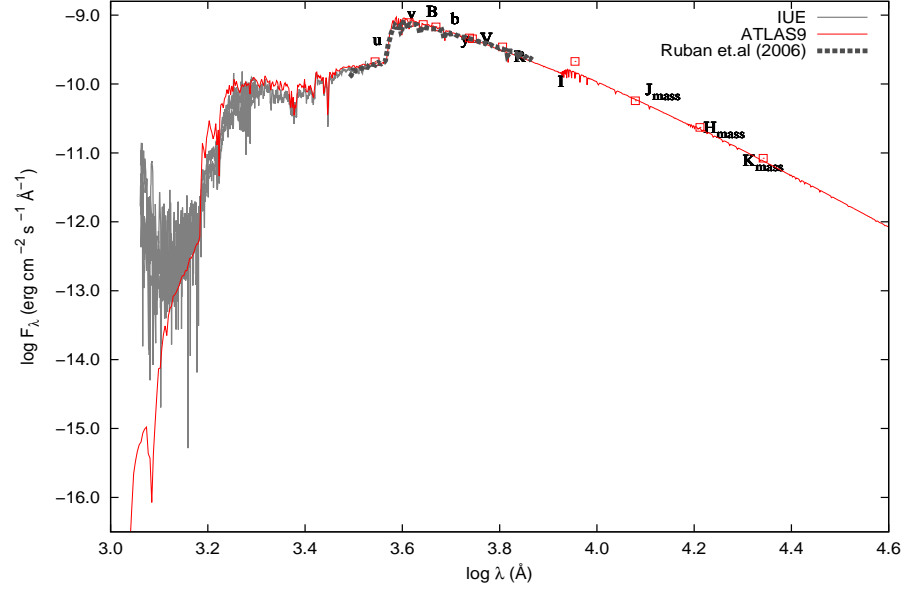


Figure 1: A comparison of the observed and computed fluxes ( $T_{\text{eff}} = 7700$  K,  $\log g = 1.60$ ) for HD 80404. ATLAS9 model flux, ATLAS9 reddened model flux, IUE spectra, the spectrophotometric data of Ruban et al. (2006) and the photometric data are also given.



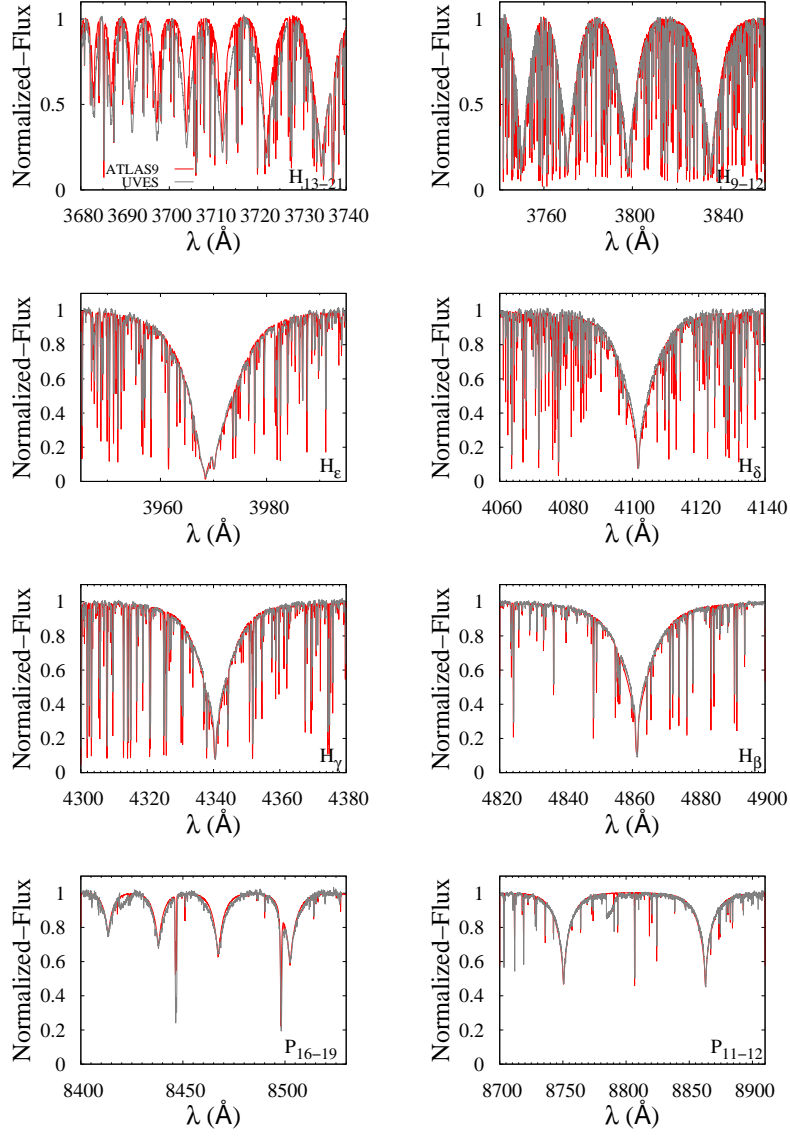


Figure 2: Synthetic spectrum fits of Balmer and Paschen series in the UVES spectra of HD 80404 for  $T_{\text{eff}} = 7700$  K,  $\log g = 1.60$  pair.

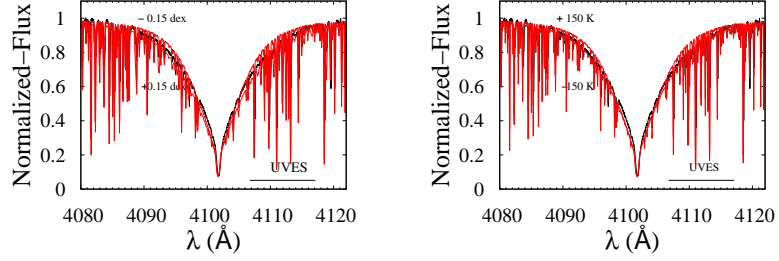


Figure 3: Synthetic spectrum fits of  $H_{\delta}$  lines in HD 80404 spectra using  $T_{\text{eff}} = 7700 (\pm 150 \text{ K})$ ,  $\log g = 1.60 (\pm 0.15 \text{ dex})$ , synthetic spectrum and UVES spectrum.

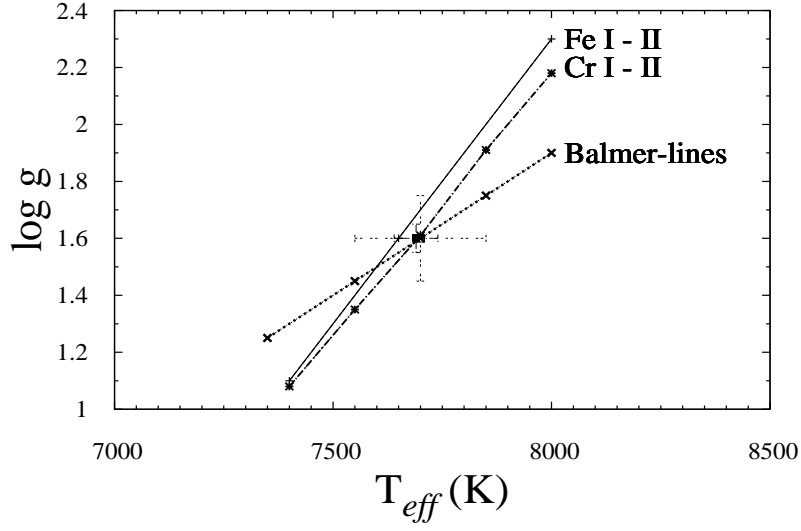


Figure 4:  $T_{\text{eff}} - \log g$  planes for  $T_{\text{eff}} = 7700 \text{ K}$ ,  $\log g = 1.60$  of HD 80404 based on Cr I/II, Fe I/II ionization levels and Balmer line fits.

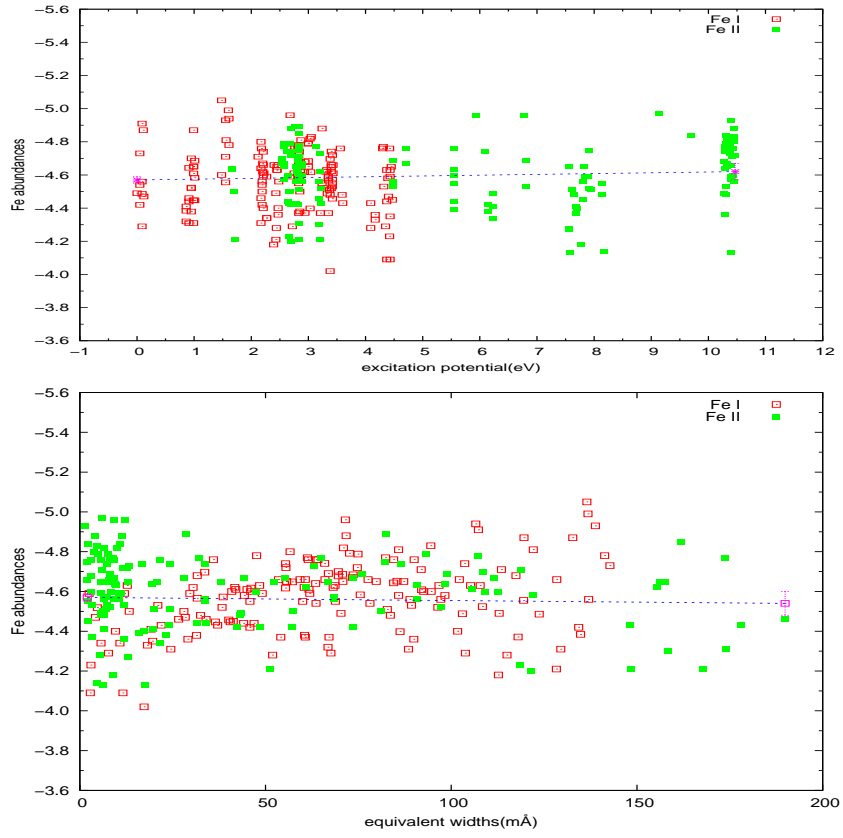


Figure 5: Fe abundances versus their equivalent widths and the different excitation potential values are plotted. The correlation between excitation potentials and Fe abundances is minimum at  $T_{\text{eff}} = 7700$  K.

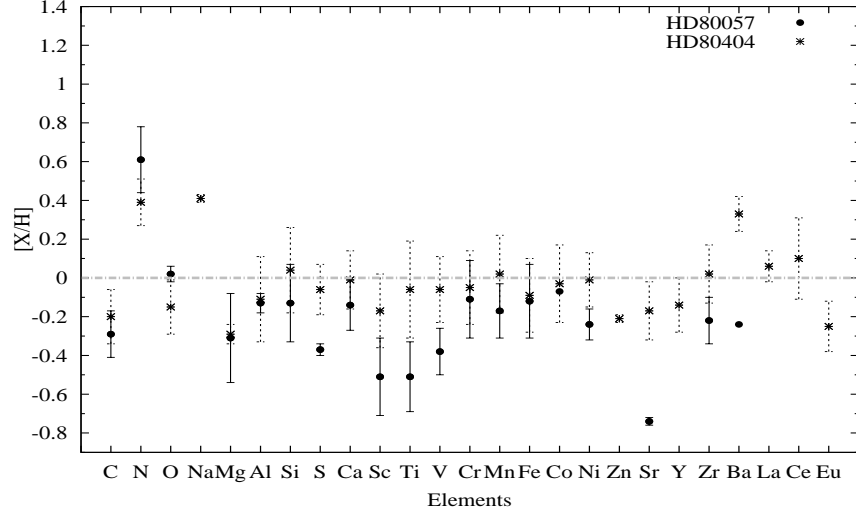


Figure 6: The chemical abundances of HD 80057 and HD 80404 compared to the solar values in Grevesse & Sauval (1996).

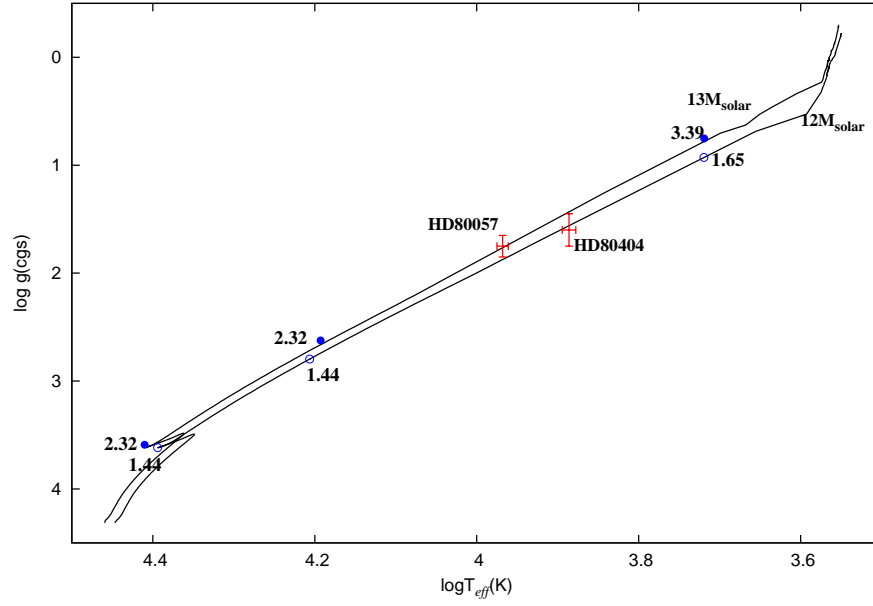


Figure 7: The positions of HD 80057 and HD 80404 on  $\log T_{\text{eff}}$   $\log g$  plane, and evolutionary tracks for 12 and 13  $M_{\odot}$ , found by interpolation between existing tracks of Geneva stellar models Georgy et al. (2013). We labelled certain  $N/C$  values (by mass ratio) on each of the tracks for comparison with our measurements.

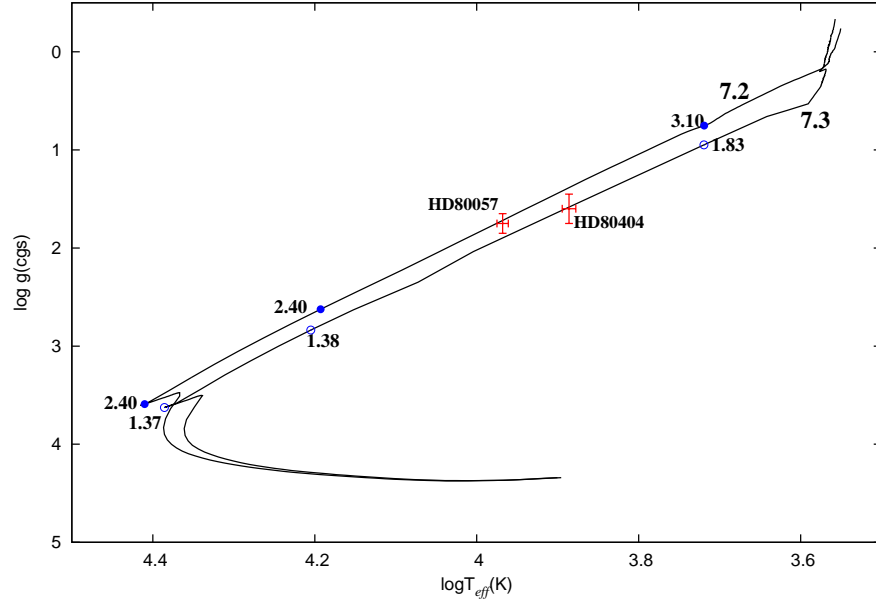


Figure 8: The positions of HD 80057 and HD 80404 on  $\log T_{\text{eff}} - \log g$  plane, and two isochrones ( $10^{7.2}$  and  $10^{7.3}$  years) computed by making use of Geneva stellar models Georgy et al. (2013) in solid curves. We labelled certain  $N/C$  values (by mass ratio) on each of the isochrones for comparison with our measurements.

Table 1: Stellar parameters of HD 80057 and HD 80404 from other authors.

	HD 80057	HD 80404
<b>Basic</b>		
Name	...	$\iota$ Car
Association	Vela OB1 <sup>a</sup>	...
Spectral type	A1-Iab <sup>b</sup>	A8-Ib <sup>f</sup>
Distance (kpc)	$1.449 \pm 0.819, 1.839$ <sup>c,b</sup>	$0.235 \pm 0.005$ <sup>c</sup>
Radial velocity (km s <sup>-1</sup> )	$25.7 \pm 2.0$ <sup>d</sup>	$12.0 \pm 0.3$ <sup>d</sup>
<b>Atmospheric</b>		
$T_{\text{eff}}$ (K)	$9300 \pm 150$ <sup>b</sup>	$7500 \pm 200$ <sup>g</sup>
log $g$ (cgs)	$1.75 \pm 0.10$ <sup>b</sup>	$2.40 \pm 0.25$ <sup>g</sup>
$\xi$ (km s <sup>-1</sup> )	$5 \pm 1$ <sup>b</sup>	$2.35 \pm 0.35$ <sup>g</sup>
$\zeta$ (km s <sup>-1</sup> )	$27 \pm 5$ <sup>b</sup>	...
$v \sin i$ (km s <sup>-1</sup> )	$13 \pm 5$ <sup>b</sup>	$10.0 \pm 0.6$ <sup>d</sup>
<b>Photometric</b>		
<b>(Johnson)</b>		
$V$	$6.^m044 \pm 0.^m016$ <sup>b</sup>	$2.^m26$ <sup>h</sup>
$B - V$	$0.^m285 \pm 0.^m006$ <sup>b</sup>	$0.^m18$ <sup>h</sup>
$U - B$	$-0.^m117 \pm 0.^m021$ <sup>b</sup>	$0.^m16$ <sup>h</sup>
<b>(Strömgren)</b>		
$b - y$	$0.267 \pm 0.003$ <sup>e</sup>	$0.123 \pm 0.007$ <sup>i</sup>
$m_1$	$-0.009 \pm 0.011$ <sup>e</sup>	$0.130 \pm 0.009$ <sup>i</sup>
$c_1$	$0.861 \pm 0.007$ <sup>e</sup>	$1.542 \pm 0.011$ <sup>i</sup>
$M_V$	$-6.^m40 \pm 0.^m18$ <sup>a</sup>	$-5.^m1$ <sup>j</sup>
$(m - M)_0$	$9.^m52 \pm 0.^m18$ <sup>a</sup>	$7.^m2$ <sup>j</sup>
$M_{\text{bol}}$	$-6.^m49 \pm 0.^m18$ <sup>a</sup>	$-5.^m3$ <sup>k</sup>
$BC$	$-0.^m09$	$0.^m21$ <sup>k</sup>
$E(B - V)$	$0.^m32 \pm 0.02$ <sup>b</sup>	$0.^m13$ <sup>j</sup>
$\theta_D(mas)$	...	$1.^m55 \pm 0.12$ <sup>l</sup>

<sup>a</sup>Reed (2000), <sup>b</sup>Firnstein & Przybilla (2012), <sup>c</sup>van Leeuwen (2007), <sup>d</sup>Gontcharov (2006),  
<sup>e</sup>Hauck & Mermilliod (1998), <sup>f</sup>Tetzlaff et al. (2011), <sup>g</sup>Smiljanic et al. (2006), <sup>h</sup>Ducati (2002),  
<sup>i</sup>Arellano Ferro & Mantegazza (1996), <sup>j</sup>Snow et al. (1994) <sup>k</sup>van der Wal & van Genderen  
(1988) <sup>l</sup>Davis et al. (2009)

Table 2: Atmospheric parameters of HD 80057 and HD 80404 from various sources.

Source	$T_{\text{eff}}$ (K)	$\log g$	$\xi$ (km s <sup>-1</sup> )	$\zeta$ (km s <sup>-1</sup> )	Spectra	Method
<u>HD 80057</u>						
Firnstein & Przybilla (2012)	9300 ± 150	1.75 ± 0.10	5 ± 1	27	FEROS, R~40000 3500-9300 Å, S/N > 150	NLTE
<u>iota Car</u>						
Boiarchuk & Liubimkov (1984)	7300 ± 200	1.40 ± 0.10	...	...	reciprocal dispersion, 2 Å/mm	LTE, Kurucz (1979)
Luck & Lambert (1985)	7500	0.90	2.5	1		LTE, Fe I/II ionization balance
Luck & Lambert (1992)	7500	1.6	2.2	1	CTIO, R~18000	LTE
Smiljanic et al. (2006)	7500	2.40	2.34	...	FEROS, R=48000 3500-9200 Å, S/N > 150	LTE, $H_{\alpha}$ , and Fe I/II ionization balance

Table 3: The comparison of derived abundances of target stars relative to the solar values and literature.

Species	Solar <sup>1</sup>		HD 80057		HD 80404			
		n	This Study	FP <sup>2,3</sup>	n	This Study	n	LL <sup>4,5</sup>
C I	-3.45	5	-3.72±0.22	-3.78±0.08	12	-3.65±0.14	...	-3.67
C II	-3.45	2	-3.78±0.04	-3.72±0.13	...	...	...	...
N I	-4.03	1	-3.42±0.17	-3.66±0.04	3	-3.52±0.14	...	-3.72
N II	-4.03	...	...	-3.71	...	...	...	...
O I	-3.13	3	-3.11±0.04	...	14	-3.34±0.24	3	-3.38
Na I	-5.67	...	...	...	3	-5.26±0.02	2	-5.19±0.03
Mg I	-4.42	2	-4.78±0.22	-4.58±0.06	1	-4.67	10	-4.35±0.23
Mg II	-4.42	5	-4.71±0.08	-4.60±0.06	4	-4.72±0.05	...	...
Al I	-5.53	2	-6.08±0.05	...	2	-5.56±0.22	1	-5.58
Al II	-5.53	1	-6.03	...	1	-5.81	...	...
Si I	-4.45	...	...	...	2	-4.16±0.00	27	-4.23±0.16
Si II	-4.45	11	-4.57±0.20	...	7	-4.66±0.22	...	...
S I	-4.67	...	...	...	3	-4.63±0.08	9	-4.63±0.14
S II	-4.67	2	-5.04±0.03	...	3	-4.82±0.10	...	...
Ca I	-5.64	1	-5.75	...	24	-5.64±0.15	12	-5.57±0.17
Ca II	-5.64	2	-5.79±0.16	...	3	-5.75±0.02	3	-5.54±0.40
Sc II	-8.83	7	-9.34±0.20	...	26	-9.00±0.20	5	-9.05±0.13
Ti I	-6.98	...	...	...	40	-6.89±0.24	...	...
Ti II	-6.98	43	-7.49±0.18	...	59	-7.15±0.21	1	-7.05
V I	-8.00	...	...	...	4	-8.05±0.11	...	...
V II	-8.00	7	-8.38±0.12	...	25	-8.06±0.18	...	...
Cr I	-6.33	...	...	...	40	-6.40±0.19	...	...
Cr II	-6.33	50	-6.44±0.17	...	59	-6.37±0.18	...	...
Mn I	-6.61	...	...	...	25	-6.56±0.22	...	...
Mn II	-6.61	8	-6.78±0.14	...	11	-6.66±0.11	...	...
Fe I	-4.50	25	-4.70±0.21	...	161	-4.59±0.18	61	-4.29±0.19
Fe II	-4.50	105	-4.62±0.18	...	139	-4.58±0.20	12	-4.30±0.16
Fe III	-4.50	3	-4.69±0.06	...	...	...	...	...
Co I	-7.08	...	...	...	7	-7.17±0.15	...	...
Co II	-7.08	1	-7.15	...	5	-6.95±0.20	...	...
Ni I	-5.75	...	...	...	17	-5.73±0.12	...	...
Ni II	-5.75	3	-5.99±0.08	...	3	-5.92±0.08	...	...
Zn I	-7.40	...	...	...	2	-7.61±0.02	...	...
Sr II	-9.03	2	-9.77±0.02	...	4	-9.20±0.15	...	...
Y II	-9.76	...	...	...	15	-9.90±0.10	1	-9.61±0.03
Zr II	-9.40	3	-9.62±0.12	...	17	-9.42±0.15	...	...
Ba II	-9.87	1	-10.11	...	4	-9.54±0.09	2	-9.40±0.09
La II	-10.83	...	...	...	12	-10.77±0.08	...	...
Ce II	-10.42	...	...	...	9	-10.32±0.21	...	...
Eu II	-11.49	...	...	...	4	-11.74±0.13	2	-11.12±0.02
$T_{\text{eff}}$ (K)	...	...	9300	...	...	7700	...	...
log $g$ (cgs)	...	...	1.75	...	...	1.60	...	...

1. Grevesse &amp; Sauval (1996), 2. Firnstein &amp; Przybilla (2012),

3. Grevesse &amp; Sauval (1998), 4. Luck &amp; Lambert (1992), 5. Grevesse (1984)



Table 4: Microturbulence determinations from various elements/ions

Element	n	$\xi_1$ (scatter) km s <sup>-1</sup>	log (N/N <sub>T</sub> )	$\xi_2$ (slope) km s <sup>-1</sup>	log (N/N <sub>T</sub> )	Reference
HD 80057						
Fe II	105	4.3	-4.62±0.18	4.4	-4.62±0.18	KX+ N4
avg		4.4				+VALD
stdev		0.1				
HD 80404						
C I	13	4.1	-3.71±0.15	4.0	-3.71±0.15	WF
adopted		4.1				
Ca I	39	2.2	-5.67±0.12	2.2	-5.67±0.12	FW+WS
adopted		2.2				
Fe I	152	2.0	-4.56±0.16	2.0	-4.56±0.16	KX+ N4
adopted		2.0				+VALD
Fe II	139	2.3	-4.63±0.17	2.4	-4.59±0.18	KX+N4
adopted		2.4				+VALD
Cr I	40	1.7	-6.36±0.18	1.7	-6.36±0.18	MF
adopted		1.7				
Cr II	58	2.0	-6.32±0.17	2.0	-6.32±0.17	MF+KX
adopted		2.0				+NL
Sr II	4	1.8	-9.02±0.10	1.9	-9.02±0.10	B+WM
adopted		1.9				
Y II	15	1.7	-9.77±0.13	1.8	-9.77±0.14	HL
adopted		1.7				
Zr II	17	1.7	-9.33±0.12	1.7	-9.33±0.12	LN+BG
adopted		1.7				
avg		2.2				
stdev		0.7				

References of gf-values: B= Brage et al. (1998) ; BG = Biemont et al. (1981);  
 HL = Hannaford et al. (1982);  
 FW = Fuhr & Wiese (2002) and Fuhr et al. (1988);  
 KX = Kurucz (1995), LN = Ljung et al. (2006);  
 NL = Nilsson et al. (2006), N4 = Fuhr & Wiese (2006),  
 MF = Fuhr et al. (1988) and Martin et al. (1988);  
 WF = Wiese et al. (1996); WM = Wiese & Martin (1980), WS = Wiese et al. (1969);  
 VALD, VALD2 data= Piskunov et al. (1995), Ryabchikova et al. (1997),  
 Kupka et al. (1999), Kupka et al. (2000);

Table 5: Error reasons for the abundances of HD 80404

Species	$\sigma (T_{\text{eff}})$ (+ 150K)	$\Delta (\log g)$ (+ 0.15 dex)	$\Delta (\xi)$ (+ 0.7 km s <sup>-1</sup> )	EW (10%EW)	$\sigma_{TOTAL}$
C I	0.06	-0.04	-0.02	0.07	0.10
N I	0.06	0.01	0.04	0.08	0.08
O I	0.00	0.01	-0.02	0.04	0.04
Na I	0.11	-0.07	-0.03	0.06	0.14
Mg I	0.13	-0.08	-0.14	0.02	0.20
Mg II	0.00	0.02	-0.09	0.03	0.10
Al I	0.15	-0.07	-0.31	-0.13	0.37
Al II	-0.05	0.07	-0.02	0.03	0.09
Si I	0.12	-0.07	-0.01	0.04	0.15
Si II	-0.02	0.04	-0.10	0.01	0.11
S I	0.11	-0.07	-0.01	0.05	0.14
S II	-0.10	0.18	-0.02	0.06	0.19
Ca I	0.17	-0.10	-0.05	0.07	0.22
Ca II	0.06	-0.10	-0.07	0.08	0.12
Sc II	0.10	-0.01	-0.14	0.12	0.21
Ti I	0.16	-0.08	-0.01	0.00	0.19
Ti II	0.10	0.02	-0.16	0.16	0.25
V I	0.16	-0.08	-0.01	0.04	0.18
V II	0.08	0.00	-0.09	0.09	0.15
Cr I	0.16	-0.07	-0.04	0.04	0.19
Cr II	0.05	0.01	-0.11	0.10	0.16
Mn I	0.14	-0.08	-0.05	0.07	0.18
Mn II	0.03	0.01	-0.03	0.05	0.07
Fe I	0.15	-0.09	-0.13	0.13	0.25
Fe II	0.06	0.06	-0.05	0.13	0.16
Co I	0.17	-0.07	-0.03	0.06	0.20
Co II	0.02	-0.04	-0.17	0.06	0.19
Ni I	0.13	-0.08	-0.02	0.05	0.16
Ni II	0.04	0.02	-0.04	0.07	0.09
Zn I	0.14	-0.07	0.00	0.05	0.16
Sr II	0.17	-0.04	-0.33	0.18	0.41
Y II	0.04	-0.01	-0.10	0.10	0.15
Zr II	0.03	0.00	0.06	0.08	0.10
Ba II	-0.08	0.12	-0.30	0.19	0.38
La II	0.14	-0.04	-0.03	0.06	0.16
Ce II	0.13	-0.03	-0.02	0.05	0.14
Eu II	0.17	-0.04	-0.02	0.05	0.18

$$\sigma_{tot.}^2 = \sigma_{teff}^2 + \sigma_{logg}^2 + \sigma_{EW}^2 + \sigma_{\xi}^2$$

Table 6: Elemental Abundances of HD 80057 and HD 80404

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>	$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>
C I					log C/N <sub>T</sub> = -3.72±0.22			-3.65±0.14
	6	4771.74	-1.87	FW	...	...	74.4	-3.47
		4775.90	-2.90	FW	...	...	37.7	-3.47
	13	5052.17	-1.30	CR	...	...	69.9	-3.90
		4932.05	-1.66	FW	...	...	47.2	-3.84
	14	4371.27	-1.96	FW	...	...	31.8	-3.75
	17	4228.32	-2.27	FW	...	...	20.9	-3.64
	26	7111.47	-1.09	FW	7.0	-3.44	42.8	-3.72
		7113.18	-0.77	FW	3.8	-4.03	67.3	-3.73
	25.02	7108.93	-1.59	FW	...	...	24.7	-3.53
	25.02	7115.17	-0.94	FW	4.0	-3.83	67.7	-3.55
C I	25.02	7116.99	-0.91	FW	4.5	-3.82	68.4	-3.57
	25.02	7119.66	-1.15	FW	5.5	-3.49	50.7	-3.55
C II					log C/N <sub>T</sub> = -3.78±0.04			...
	4	3918.97	-0.53	WF	13.6	-3.82	...	...
	6	4267.26	+0.74	WF	28.8	-3.74	...	...
N I					log N/N <sub>T</sub> = -3.36±0.18			-3.61±0.12
	6	4151.48	-1.98	WF	3.2	-3.66	7.9	-3.69
	9	4914.94	-2.23	WF	...	...	4.3	-3.44
		4935.12	-1.89	WF	...	...	5.2	-3.69

Note: gf value references follow:

AT = Aldenius et al. (2007); B= Brage et al. (1998) BB= Blackwell-Whitehead & Bergemann (2007);  
 BG = Biemont et al. (1981), Biemont et al. (1989); CB = Corliss & Bozman (1962); CR = Wiese & Fuhr (2007)  
 DS = Davidson et al. (1992) FW = Fuhr & Wiese (2002) and Fuhr et al. (1988); HL = Hannaford et al. (1982)  
 JK = Jönsson et al. (1984) KG = Kling & Griesmann (2000); KS = Kling et al. (2001); KX = Kurucz (1995)  
 LA = Lanz & Artru (1985); LB = Lawler et al. (2001) LD = Lawler & Dakin (1989); LN = Ljung et al. (2006)  
 LW = Lawler et al. (2001); MC = Meggers et al. (1975); NL = Nilsson et al. (2006)  
 N4 = Fuhr & Wiese (2006); MF = Fuhr et al. (1988) and Martin et al. (1988); RP = Raassen et al. (1998)  
 PT = Pickering et al. (2001); Pickering et al. (2002); PQ= Palmeri et al. (2000); SG = Schulz-Gulde (1969)  
 WF = Wiese et al. (1996); WM = Wiese & Martin (1980); WS = Wiese et al. (1969);  
 VALD, VALD2 data= Piskunov et al. (1995), Ryabchikova et al. (1997), Kupka et al. (1999), Kupka et al. (2000)

-The lines marked with \* are ignored in average calculations.

-This table is given electronically.

Table 7: The derived abundances and stellar parameters of HD 80057 and HD 80404 based on isochrones and evolutionary tracks of Georgy et al. (2013) for  $\Omega / \Omega_{crit} = 0.65, 0.50$  and our abundance analysis.

	HD80057	HD80404
$\Omega$	0.60	0.50
N/C	$2.44 \pm 0.91$	$1.58 \pm 0.07$
predicted	$2.39 \pm 0.05$	$1.48 \pm 0.01$
N/O	$0.43 \pm 0.17$	$0.50 \pm 0.30$
predicted	$0.52 \pm 0.01$	$0.49 \pm 0.12$
$\Sigma CNO$	$0.07 \pm 0.10$	$-0.05 \pm 0.08$
M/H	$-0.15 \pm 0.24$	$-0.02 \pm 0.20$
$v_{crit}$	$147 \pm 1$	$131 \pm 3$
$v \sin i$	$25 \pm 3$	$21 \pm 1$
$R / R_{\odot}$	$86 \pm 3$	$96 \pm 10$
$M^{spec} / M_{\odot}$	$13 \pm 1$	$13 \pm 2$
$M^{ZAMS} / M_{\odot}$	$13 \pm 1$	$12 \pm 2$
$M^{evol} / M_{\odot}$	$13.00 \pm 0.30$	$11.80 \pm 0.20$
$\log L / L_{\odot}$	$4.63 \pm 0.04$	$4.46 \pm 0.02$

Table A1: Elemental Abundances of HD 80057 and HD 80404

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>	$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>
C I					log C/N <sub>T</sub> = -3.72±0.22			-3.65±0.14
	6	4771.74	-1.87	FW	...	...	74.4	-3.47
		4775.90	-2.90	FW	...	...	37.7	-3.47
	13	5052.17	-1.30	CR	...	...	69.9	-3.90
		4932.05	-1.66	FW	...	...	47.2	-3.84
	14	4371.27	-1.96	FW	...	...	31.8	-3.75
	17	4228.32	-2.27	FW	...	...	20.9	-3.64
	26	7111.47	-1.09	FW	7.0	-3.44	42.8	-3.72
		7113.18	-0.77	FW	3.8	-4.03	67.3	-3.73
	25.02	7108.93	-1.59	FW	...	...	24.7	-3.53
	25.02	7115.17	-0.94	FW	4.0	-3.83	67.7	-3.55
	25.02	7116.99	-0.91	FW	4.5	-3.82	68.4	-3.57
	25.02	7119.66	-1.15	FW	5.5	-3.49	50.7	-3.55
					log C/N <sub>T</sub> = -3.78±0.04			...
C I	4	3918.97	-0.53	WF	13.6	-3.82	...	...
	6	4267.26	+0.74	WF	28.8	-3.74	...	...
					log N/N <sub>T</sub> = -3.36±0.18			-3.61±0.12
N I	6	4151.48	-1.98	WF	3.2	-3.66	7.9	-3.69
	9	4914.94	-2.23	WF	...	...	4.3	-3.44
		4935.12	-1.89	WF	...	...	5.2	-3.69
O I					log O/N <sub>T</sub> = -3.11±0.04			-3.34±0.24
	3	3947.29	-2.10	WF	...	...	23.7	-3.53
		3947.48	-2.29	WF	...	...	11.0	-3.77
	5	4368.27	-1.70	WF	...	...	38.4	-3.39
	9	6453.60	-1.29	WF	...	...	16.1	-3.25
		6454.44	-1.07	WF	...	...	23.8	-3.26
	10	6155.98	-0.66	WF	46.5	-3.16	39.7	-3.40
		6156.77	-0.44	WF	69.3	-3.11	54.7	-3.39
		6158.19	-0.30	WF	87.7	-3.06	67.0	-3.36
	13	5018.78	-2.09	WF	...	...	7.0	-3.03
		5019.29	-1.87	WF	...	...	10.8	-3.04
		5020.13	-1.73	WF	...	...	13.1	-3.09
	15	4803.00	-1.98	WF	...	...	9.4	-3.03
	16	4772.45	-1.92	WF	...	...	2.1	-3.77
		4773.75	-1.55	WF	...	...	8.4	-3.51
					log Na/N <sub>T</sub> = -4.56±0.02			-5.26±0.02
Na I	6	5682.63	-0.70	WF	...	...	46.9	-5.29
		5688.20	-0.45	WF	...	...	69.7	-5.24
	11	4751.82	-2.09	WF	...	...	2.9	-5.26
Mg I					log Mg/N <sub>T</sub> = -4.68±0.16			-4.67
	11	4702.99	-0.38	WS	6.9	-4.84	111.3	-4.67
	15	4167.27	-0.79	JK	5.2	-4.53	...	...
Mg II					log Mg/N <sub>T</sub> = -4.71±0.08			-4.72±0.05
	5	3848.24	-1.57	FW	40.0	-4.67	42.2	-4.69
		3850.39	-1.88	FW	26.1	-4.60	30.6	-4.59
	9	4428.00	-1.21	WS	17.9	-4.83	21.9	-4.69
		4433.99	-0.91	FW	36.7	-4.74	36.7	-4.66
	18	4739.59	-0.64	KX	...	...	6.7	-4.89
	20	5401.52	-0.08	KX	30.1	-4.71	...	...
					log Al/N <sub>T</sub> = -6.08±0.05			-5.56±0.22
Al I	1	3944.01	-0.64	WS	27.2	-6.03	175.2	-5.64
	2	3961.52	-0.34	WS	39.2	-6.13	166.8	-6.08
Al II					log Al/N <sub>T</sub> = -6.03			-5.81
	2	4663.10	-0.28	FW	31.0	-6.03	16.0	-5.81
Si I					log Si/N <sub>T</sub> = ...			-4.21±0.07
	1	5645.67	-2.14	VALD2	...	...	7.5	-4.17
		5665.55	-2.04	VALD2	...	...	9.4	-4.17
		5690.47	-1.87	VALD2	...	...	12.5	-4.20
	2	5701.10	-2.05	VALD2	...	...	9.4	-4.16
		5708.43	-1.47	VALD2	...	...	28.9	-4.16
	5	6145.01	-1.31	VALD2	...	...	13.4	-4.22
		6155.13	-0.75	VALD2	...	...	27.8	-4.41
Si II					log Si/N <sub>T</sub> = -4.57±0.20			-4.80±0.23
	1	3853.66	-1.44	LA	160.0	-4.58	92.0	-4.78
		3856.02	-0.49	LA	290.9	-4.06	143.2	...
		3862.59	-0.74	LA	288.5	-3.83	131.8	...
	2	6347.09	0.23	CR	...	...	204.8	-4.32
		6371.36	-0.08	CR	...	...	159.1	-4.43
	3	4128.02	-1.40	CR	203.0	-4.08	102.4	-4.69
		4130.00	-1.40	CR	210.7	-4.17	95.0	-4.94
	5	5041.02	0.17	CR	148.9	-4.04	48.9	-4.96
		5056.00	0.44	CR	...	...	79.6	-4.75

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>	$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>
Si II	(continued)							
	5	5056.35	-0.53	WS	57.8	-4.26	33.8	-4.53
	-	4075.45	-1.40	SG	25.0	-4.66	6.8	5.05
	7.05	4621.42	-0.54	WS	13.1	-4.77	2.3	-4.82
		4621.72	-0.38	WS	5.7	-4.56	2.6	-4.93
	7.15	4673.27	-0.35	KX	8.0	-4.56	...	...
	7.26	4190.70	-0.35	KG	5.8	-4.75	9.9	...
	7.26	4198.13	-0.30	KG	10.9	-4.77	...	...
S I					log S/N <sub>T</sub> = ...			-4.63±0.08
	2	4694.11	-1.77	CR	...	...	19.1	-4.58
		4695.44	-1.92	CR	...	...	14.5	-4.57
		4696.25	-2.14	CR	...	...	6.3	-4.74
S II					log S/N <sub>T</sub> = -5.04±0.03			-4.82±0.10
	7	5032.45	0.28	WS	...	...	2.4	-4.94
	44	4153.09	0.62	WS	10.8	-5.07	2.6	-4.82
		4162.67	0.78	WS	14.2	-	3.8	-4.71
Ca I					log Ca/N <sub>T</sub> = -5.75			-5.64±0.15
	2	4226.73	+0.24	FW	9.7	-5.75	172.0	-5.67
	4	4425.44	-0.36	WS	...	...	59.3	-5.63
		4434.96	-0.01	WS	...	...	70.1	-5.85
		4455.89	-0.53	WS	...	...	54.4	-5.54
	5	4283.01	-0.22	WS	...	...	63.9	-5.71
		4289.36	-0.30	WS	...	...	54.6	-5.76
		4298.99	-0.41	WS	...	...	61.0	-5.56
		4302.53	0.28	WS	...	...	100.2	-5.66
		4318.63	-0.21	WS	...	...	59.1	-5.78
	23	4578.56	-0.56	WS	...	...	16.6	-5.74
		4581.40	-0.34	WS	...	...	24.5	-5.76
		4585.87	-0.19	WS	...	...	33.2	-5.74
		4585.92	-1.26	WS	...	...	5.5	-5.56
	25	4092.63	-0.84	CR	...	...	11.7	-5.57
		4094.93	-0.69	CR	...	...	12.2	-5.69
		4098.56	-0.54	CR	...	...	17.4	-5.42
	26	3870.50	-0.84	FW	...	...	5.3	-5.68
		3875.80	-0.69	FW	...	...	17.5	-5.42
	34	5041.61	-0.42	WS	...	...	19.7	-5.68
	35	4878.12	-0.33	WS	...	...	24.9	-5.64
	36	4526.92	-0.43	WS	...	...	17.3	-5.72
	37	4355.07	-0.43	WS	...	...	16.9	-5.71
	39	4108.52	-0.69	VALD	...	...	7.0	-5.79
	51	4685.26	-0.88	WS	...	...	17.7	-5.12
Ca II					log Ca/N <sub>T</sub> = -5.79±0.16			-5.75±0.02
	15	5001.49	-0.52	KX	6.3	-5.95	61.8	-5.78
		5019.98	-0.26	KX	21.6	-5.63	81.6	-5.75
		5021.13	-1.22	KX	...	...	22.2	-5.73
Sc II					log Sc/N <sub>T</sub> = -9.34±0.20			-9.00±0.20
	4	3352.04	-1.87	VALD	...	...	23.1	-9.13
		3368.93	-0.29	VALD	...	...	90.2	-9.14
	7	4246.82	+0.24	LD	42.6	-9.69	...	...
	14	4354.59	-1.58	LD	...	...	59.7	-9.01
		4374.42	-0.42	VALD2	22.2	-9.18	...	...
		4384.81	-1.61	VALD2	...	...	32.2	-9.45
		4400.36	-0.54	VALD2	9.3	-9.48	144.1	-8.69
		4415.56	-0.68	LD	...	...	120.9	-8.99
		4420.66	-2.27	VALD2	...	...	22.3	-9.07
	14	4431.35	-1.97	VALD	...	...	37.6	-8.93
	15	4279.92	-1.39	LD	...	...	8.3	-8.94
	15	4294.77	-1.39	LD	...	...	72.3	-9.03
		4305.71	-1.30	LD	...	...	82.9	-9.05
		4314.08	-0.09	LD	...	...	145.3	-9.33
		4320.70	-0.26	LD	24.5	-9.30	144.5	-9.19
		4324.99	-0.44	MF	17.4	-9.29	131.2	-9.24
	24	4670.40	-0.58	LD	8.1	-9.04	...	...
	23	5031.02	-0.40	LD	...	...	102.1	-9.10
	26	5239.81	-0.77	LD	...	...	69.1	-9.16
	28	6245.63	-1.02	VALD2	...	...	52.7	-9.14
		6279.75	-1.25	VALD2	...	...	34.9	-9.17
		6300.69	-1.62	VALD2	...	...	10.6	-9.13
		6309.92	-1.62	VALD2	...	...	9.6	-9.46
		6320.85	-1.82	VALD2	...	...	13.7	-9.09
	29	5641.00	-1.13	VALD	...	...	56.8	-9.02
		5657.89	-0.60	VALD	...	...	104.8	-9.00
		5658.36	-1.21	VALD	...	...	42.4	-9.08
		5667.14	-1.31	VALD	...	...	44.8	-8.97
		5669.04	-1.20	VALD	...	...	77.7	-8.70
		5684.20	-1.07	VALD	...	...	57.4	-9.00
	31	5526.90	-0.02	VALD	8.0	-9.42	124.5	-9.10

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>	$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>
Ti I	6	4656.46	-1.35	WS	log Ti/N <sub>T</sub> = ...		-7.53±0.21	
		4667.58	-1.19	WS	...	...	6.2	-6.63
		4681.90	-1.07	WS	...	...	3.5	-7.03
		3982.48	-1.27	WS	...	...	5.2	-6.96
		3981.76	-0.35	WS	...	...	10.7	-6.40
	11	3998.63	-0.06	WS	...	...	56.4	-6.37
		3989.75	-0.20	WS	...	...	30.0	-7.04
		3964.26	-1.18	WS	...	...	50.9	-6.58
	12	3924.52	-0.94	WS	...	...	3.5	-6.98
		3929.87	-1.06	WS	...	...	6.7	-6.92
		3948.67	-0.47	WS	...	...	4.8	-6.97
		3956.33	-0.45	WS	...	...	21.2	-6.85
		4981.73	+0.50	WS	...	...	14.6	-7.05
	13	4991.06	+0.38	WS	...	...	30.6	-7.07
		4999.50	+0.25	WS	...	...	38.4	-6.53
		5007.20	+0.11	WS	...	...	25.1	-6.95
		5014.27	+0.11	WS	...	...	55.7	-6.32
		5016.16	-0.57	WS	...	...	19.5	-6.95
	38	5022.87	-0.43	WS	...	...	3.0	-7.12
		5024.84	-0.60	WS	...	...	3.9	-7.16
		4512.73	-0.48	WS	...	...	6.4	-7.14
		4518.02	-0.33	WS	...	...	10.5	-6.61
		4533.23	0.48	WS	...	...	14.1	-6.63
		4534.77	0.28	WS	...	...	26.3	-7.10
		4535.57	0.16	VALD	...	...	19.2	-7.08
		4535.91	-0.04	VALD	...	...	11.7	-7.21
		4536.04	-0.13	VALD	...	...	6.8	-7.27
		4548.76	-0.35	WS	...	...	7.6	-7.13
	42	4552.45	-0.34	WS	...	...	4.6	-7.13
		4552.48	-0.49	WS	...	...	13.5	-6.64
		4555.48	-0.49	WS	...	...	9.1	-6.67
		4287.40	-0.44	WS	...	...	8.5	-6.75
		4289.06	-0.38	WS	...	...	8.5	-6.81
		4290.92	-0.43	WS	...	...	12.3	-6.59
		4295.75	-0.45	WS	...	...	5.9	-6.91
		4301.08	0.26	WS	...	...	18.7	-7.05
		4305.91	0.51	VALD	...	...	32.3	-6.84
		4078.47	-0.12	VALD	...	...	5.8	-6.86
	44	4449.14	+0.50	WS	...	...	5.6	-7.03
		4450.89	+0.41	WS	...	...	5.3	-7.24
		4617.25	+0.39	WS	...	...	5.3	-6.71
	80							
	160							
Ti II						log Ti/N <sub>T</sub> = -7.49±0.18	-7.14±0.20	
	11	3981.99	-2.91	PT	9.8	-7.02	93.7	-6.78
		3987.60	-2.93	PT	2.0	-7.68	72.6	-7.07
		4012.38	-1.84	PT	62.4	-7.14	...	...
	12	4025.13	-2.14	PT	30.5	-7.22	101.6	-7.39
		3813.38	-1.83	PT	23.6	-7.64	...	...
		3814.58	-1.61	PT	40.1	-7.61	...	...
	18	4469.14	-2.33	PT	6.2	-7.51	...	...
	19	4450.49	-1.52	PT	...	...	134.3	-7.14
	20	4287.89	-1.79	PT	...	...	108.1	-7.33
		4294.09	-0.93	PT	83.6	-7.55	...	...
		4344.24	-1.91	PT	...	...	103.4	-7.30
	21	4161.53	-2.09	PT	...	...	86.7	-7.36
		4173.53	-1.88	PT	...	...	...	...
		4184.33	-2.50	PT	...	...	92.1	-6.88
	29	4190.23	-2.89	PT	...	...	31.2	-7.39
		4794.84	-4.19	VALD2	...	...	2.5	-7.31
		4849.18	-3.00	PT	...	...	47.1	-7.05
	30	4865.62	-2.79	PT	...	...	50.5	-7.22
		4506.74	-3.49	VALD2	...	...	16.7	-7.11
		4552.29	-2.89	VALD2	...	...	50.1	-7.10
	39	4549.81	-2.35	PT	...	...	100.6	-6.88
		4583.41	-2.92	PT	...	...	55.8	-6.96
		4609.26	-3.43	VALD2	...	...	21.8	-7.01
	31	4501.27	-0.77	PT	88.0	-7.67	...	...
	34	3900.56	-0.20	PT	157.5	-7.47	...	...
		3932.01	-1.64	PT	28.6	-7.41	...	...
		4417.72	-1.19	PT	42.8	-7.67	140.5	-7.28
	40	4441.73	-2.33	PT	8.4	-7.31	78.1	-7.22
		4464.45	-1.81	PT	16.8	-7.53	118.3	-7.10
		4470.84	-2.02	PT	13.4	-7.42	...	...
	41	4300.06	-0.44	PT	128.5	-7.58	...	...
		4301.93	-1.15	PT	31.8	-7.86	136.9	-7.37
		4307.90	-1.02	PT	74.0	-7.45	...	...
		4312.86	-1.10	PT	58.8	-7.56	...	...
		4314.97	-1.08	PT	62.6	-7.53	...	...
	48	4763.88	-2.36	PT	...	...	75.8	-7.23
	50	4533.97	-0.53	PT	153.7	-7.23	...	...
		4563.76	-0.69	PT	67.7	-7.87	...	...
		4394.06	-1.78	PT	18.2	-7.48	...	...
	51	4399.77	-1.19	PT	40.6	-7.65	...	...
		4407.68	-2.62	PT	...	...	72.0	-6.98
		4657.21	-2.24	PT	7.1	-7.45	...	...
	59							
	60	4544.02	-2.58	PT	...	...	58.1	-7.20

Table A1: - continued

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404		
					$W_\lambda(\text{m\AA})$	log $N/N_T$	$W_\lambda(\text{m\AA})$	log $N/N_T$	
Ti II	(continued)	4568.31	-2.94	PT	...	...	42.8	-7.08	
		4580.45	-2.94	PT	3.2	-7.11	33.9	-7.21	
		4600.26	-3.54	VALD2	...	...	...	...	
		4391.03	-2.28	PT	5.9	-7.49	100.2	-6.89	
		4411.93	-2.52	PT	3.2	-7.52	58.0	-7.27	
		4423.24	-2.67	KX	...	...	...	...	
		5154.07	-1.75	PT	...	...	97.1	-7.30	
		5188.68	-1.05	PT	...	...	130.2	-7.46	
		5226.54	-1.26	PT	...	...	163.6	-6.69	
		72	3757.68	-0.42	PT	83.3	-7.69	146.5	-7.30
		3776.05	-1.25	PT	18.8	-7.71	...	...	
		4529.48	-1.64	PT	19.9	-7.36	106.7	-7.19	
		4571.97	-0.32	PT	108.7	-7.65	...	...	
		86	5129.14	-1.24	PT	...	...	116.1	-7.26
		5131.28	-3.02	VALD	...	...	18.2	-7.00	
		5185.90	-1.49	PT	...	...	104.9	-7.19	
		87	4028.34	-0.96	PT	41.5	-7.43	127.4	-7.08
		4053.83	-1.13	PT	...	...	140.5	-6.63	
		92	4779.99	-1.26	VALD2	27.8	-7.29	111.5	-7.14
		4805.09	-0.96	VALD2	26.3	-7.61	144.8	-6.84	
		93	4374.83	-1.61	PT	...	...	112.3	-6.70
		4421.95	-1.66	PT	...	...	78.3	-7.21	
		94	4316.80	-1.58	PT	...	...	78.3	-7.29
		4350.80	-1.74	PT	...	...	63.8	-7.32	
		101	7214.78	-1.74	VALD	...	...	44.7	-7.26
		7355.46	-1.92	VALD	...	...	37.5	-7.19	
		104	4367.66	-0.86	PT	...	...	114.0	-7.01
		4386.84	-0.96	PT	...	...	92.0	-7.29	
		105	4163.64	-0.13	PT	58.0	-7.63	149.7	-6.96
		4171.90	-0.29	PT	53.2	-7.52	153.2	-6.72	
		4174.05	-1.26	PT	13.7	-7.25	67.5	-7.32	
		106	4064.35	-1.60	PT	4.5	-7.40	43.3	-7.32
		113	5010.21	-1.29	PT	...	...	44.5	-7.31
		5013.68	-1.91	PT	...	...	80.1	-7.36	
		5069.09	-1.82	PT	...	...	33.3	-6.94	
		5072.28	-1.06	PT	...	...	69.4	-7.17	
		114	4874.01	-0.80	PT	11.4	-7.52	...	...
		4911.18	-0.61	PT	18.4	-7.47	90.4	-7.32	
		115	4411.07	-0.67	PT	18.4	-7.40	86.0	-7.30
		4488.34	-0.51	PT	23.5	-7.43	105.9	-7.12	
V I				log $V/N_T = \dots$			-8.05±0.11		
	22	4379.24	0.58	MF	...	9.0	-8.16		
	22	4389.97	0.20	MF	...	7.4	-7.90		
	29	4111.64	0.41	MF	...	6.1	-8.15		
V II		4115.12	0.07	MR	...	4.0	-8.01		
				log $V/N_T = -8.38 \pm 0.12$			-8.06±0.18		
	9	3973.64	-1.07	BG	...	74.1	-8.35		
		3997.12	-1.23	BG	...	70.6	-8.21		
		4002.93	-1.45	BG	...	66.5	-8.09		
		4036.78	-1.59	BG	5.1	-8.32	53.4	-8.11	
	10	3916.42	-1.05	BG	11.2	-8.52	80.2	-8.27	
		3929.73	-1.59	BG	...	47.8	-8.21		
		3951.96	-0.74	BG	...	92.1	-8.35		
	11	3866.74	-1.55	BG	...	5.44	-8.14		
		3903.27	-0.94	BG	14.0	-8.50	99.7	-8.00	
		3926.50	-1.91	BG	...	27.7	-8.19		
	25	4178.39	-1.57	KX	...	36.4	-8.249		
		4190.41	-2.10	KX	...	21.6	-8.02		
		4209.76	-1.94	KX	...	36.7	-7.88		
	32	4005.71	-0.52	BG	21.0	-8.52	...	...	
		4023.39	-0.69	BG	24.7	-8.28	...	...	
		4035.63	-0.77	BG	17.6	-8.37	...	...	
	33	3878.71	-0.61	BG	...	...	114.3	-7.76	
		3884.85	-1.41	BG	...	...	33.0	-8.34	
		3914.32	-0.96	BG	...	...	89.2	-7.92	
	37	4183.44	-1.12	BG	...	...	75.5	-7.85	
		4205.08	-1.05	BG	...	...	68.1	-8.080	
		4225.23	-1.46	BG	...	...	55.0	-8.04	
	56	4528.50	-1.10	BG	...	...	63.1	-7.91	
		4564.59	-1.39	BG	3.9	-8.18	36.9	-8.01	
		4600.19	-1.52	BG	...	...	44.2	-7.71	
	199	4475.67	-1.44	BG	...	...	4.2	-7.93	
	255	4232.04	-0.59	BG	...	...	17.4	-7.94	
		4278.89	-0.71	BG	...	...	7.8	-8.18	
	Cr I				log $Cr/N_T = \dots$			-6.40±0.17	
		1	4254.33	-0.11	MF	...	...	111.1	-6.55
			4274.80	-0.23	MF	...	...	101.2	-6.63
			4289.72	-0.36	MF	...	...	92.5	-6.66
		7	5204.50	-0.21	MF	...	...	75.9	-6.44
			5206.02	+0.02	MF	...	...	81.5	-6.59
			5208.42	+0.16	MF	...	...	88.1	-6.63
		18	5247.56	-1.64	MF	...	...	8.3	-6.32
			5264.15	-1.29	MF	...	...	8.3	-6.66
			5265.72	-1.75	MF	...	...	8.6	-6.19
		5296.69	-1.40	MF	...	...	12.5	-6.35	



Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>	$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>
Cr I	(continued)				log Cr/N <sub>T</sub> = ...			-6.40±0.17
	18	5298.27	-1.15	MF	...	...	19.7	-6.38
		5300.74	-2.12	MF	...	...	4.9	-6.07
		5345.80	-0.98	MF	...	...	31.1	-6.29
		5348.31	-1.29	MF	...	...	16.8	-6.30
		5409.77	-0.72	MF	...	...	38.8	-6.40
	21	4591.39	-1.74	MF	...	...	5.0	-6.41
		4600.75	-1.26	MF	...	...	13.0	-6.42
		4613.37	-1.68	MF	...	...	9.2	-6.20
		4616.12	-1.19	MF	...	...	16.8	-6.38
		4626.18	-1.32	MF	...	...	13.2	-6.38
		4646.15	-0.70	MF	...	...	32.9	-6.48
		4651.29	-1.46	MF	...	...	9.3	-6.40
		4652.15	-1.03	MF	...	...	22.2	-6.38
	22	4337.55	-1.11	MF	...	...	14.7	-6.52
		4344.51	-0.55	MF	...	...	32.1	-6.64
		4351.05	-1.45	MF	...	...	17.8	-6.08
		4371.26	-1.09	MF	...	...	18.0	-6.41
		4384.96	-1.15	MF	...	...	16.4	-6.38
	23	3885.21	-1.36	MF	...	...	9.0	-6.45
		3886.79	-1.34	MF	...	...	3.4	-6.89
		3908.76	-1.00	MF	...	...	18.7	-6.43
		3919.16	-0.72	MF	...	...	29.7	-6.44
		3941.48	-1.34	MF	...	...	12.5	-6.28
	33	4526.44	-0.16	MF	...	...	26.2	-6.00
		4530.73	-0.27	MF	...	...	12.8	-6.26
		4535.72	-0.38	MF	...	...	8.6	-6.34
		4540.48	-0.49	MF	...	...	7.3	-6.31
		4544.60	-0.58	MF	...	...	12.9	-5.95
	35	4126.52	-0.65	MF	...	...	4.6	-6.33
	38	3963.58	0.69	MF	...	...	29.0	-6.73
Cr II					log Cr/N <sub>T</sub> = -6.45±0.18			-6.56±0.26
	18	4112.54	-3.02	KX	...	...	18.2	-6.65
		4113.24	-2.74	MF	5.0	-7.02	41.0	-6.69
	19	4051.97	-2.19	MF	28.2	-6.76	85.2	-6.57
		4087.60	-3.41	VALD	...	...	20.0	-6.43
	20	3715.17	-1.69	VALD	137.0	-6.01	124.8	-6.16
		3738.38	-1.84	VALD	59.6	-6.66	109.5	-6.16
		3754.56	-2.05	VALD	39.5	-6.70	30.8	-6.19
		3755.12	-3.38	VALD	6.0	-6.28	...	...
		3765.58	-2.34	VALD	36.0	-6.46	...	...
		3766.63	-3.20	VALD	6.2	-6.45	...	...
	21	3360.29	0.25	VALD	150.0	-6.46	...	...
		3361.76	-1.06	VALD	72.1	-6.39	...	...
		3378.33	-1.05	VALD	70.1	-6.43	...	...
		3379.37	-1.01	VALD	75.1	-6.39	...	...
	23	5246.76	-2.56	VALD	8.7	-6.62	49.6	-6.36
		5249.43	-2.75	VALD	10.6	-6.31	42.7	-6.24
		5318.41	-3.13	VALD	...	...	32.0	-6.07
		5346.53	-3.10	VALD	...	...	28.9	-6.12
		5407.60	-2.46	VALD	10.9	-6.55	49.1	-6.38
		5420.92	-2.56	VALD	10.3	-6.52	41.5	-6.45
	24	5510.78	-2.61	VALD	...	...	45.8	-6.28
		5097.31	-2.78	VALD	...	...	31.8	-6.42
		5116.04	-3.64	VALD	...	...	6.7	-6.33
		5153.49	-2.50	VALD	13.0	-6.47	57.9	-6.26
		5210.86	-2.95	KX	11.0	-6.10	36.8	-6.13
	26	5305.85	-2.16	VALD	38.8	-6.22	...	...
		4086.14	-2.64	VALD	9.3	-6.48	34.2	-6.46
		4179.42	-2.00	VALD	46.3	-6.26	...	...
		4207.36	-2.73	VALD	...	...	34.3	-6.30
	30	4812.34	-2.13	MF	23.7	-6.48	67.5	-6.41
		4824.13	-1.09	MF	132.2	-6.30	120.0	-6.60
		4836.23	-2.04	MF	30.6	-6.45	85.4	-6.25
		4848.24	-1.05	NL	112.8	-6.60	118.0	-6.69
		4856.19	-2.17	VALD	22.5	-6.47	55.9	-6.54
		4864.32	-1.47	VALD	51.0	-6.73	78.6	-6.92
		4876.41	-1.38	VALD	70.5	-6.42	84.3	-6.85
		4884.61	-2.23	VALD	...	...	57.0	-6.46
	31	4242.36	-1.36	VALD	100.7	-6.31	115.3	-6.32
		4252.63	-2.05	VALD	37.2	-6.31	67.0	-6.46
		4269.28	-2.20	VALD	24.1	-6.39	66.0	-6.33
		4275.58	-1.74	VALD	50.9	-6.45	94.5	-6.34
		4284.21	-1.86	KX	...	...	79.1	-6.48
	39	4539.62	-2.39	VALD	11.9	-6.42	41.0	-6.39
		4565.77	-1.98	VALD	20.8	-6.58	72.6	-6.34
	43	5237.32	-1.35	VALD	90.6	-6.32	114.3	-6.33
		5308.40	-2.06	VALD	19.5	-6.52	63.1	-6.40
		5313.56	-1.78	VALD	52.4	-6.28	74.3	-6.52
		5334.86	-1.83	VALD	36.0	-6.44	94.5	-6.18
	44	4555.02	-1.49	VALD	67.5	-6.40	107.2	-6.25
		4558.66	-0.66	VALD	177.8	-6.10	123.7	-6.77
		4588.22	-0.85	VALD	116.7	-6.56	134.2	-6.39

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log $N/N_T$	$W_\lambda(\text{m\AA})$	log $N/N_T$
Cr II	(continued)				log Cr/ $N_T = -6.46 \pm 0.20$			$-6.56 \pm 0.26$
	44	4592.04	-1.42	NL	51.2	-6.64	97.7	-6.49
		4616.63	-1.58	VALD	45.3	-6.56	91.7	-6.43
		4618.80	-1.00	NL	89.2	-6.68	120.0	-6.51
		4634.07	-1.24	MF	75.5	-6.57	111.0	-6.44
	177	4697.60	-1.88	MF	...	...	13.6	-6.34
	178	4715.12	-2.31	MF	...	...	6.0	-6.30
	179	4362.92	-1.79	VALD	4.9	-6.47	13.7	-6.42
	180	4222.00	-1.93	KX	...	...	...	...
	183	3979.50	-0.86	VALD	32.4	-6.50	...	...
	190	4912.46	-1.26	VALD	6.9	-6.38	18.5	-6.23
	191	4465.73	-1.28	VALD	...	...	10.8	-6.58
	192	4256.10	-1.52	VALD	5.7	-6.20	11.6	-6.21
	193	4049.14	-1.03	VALD	9.7	-6.45	30.9	-6.18
		4070.84	-0.93	VALD	18.3	-6.25	42.4	-6.07
	201	5076.14	-1.78	VALD	...	...	2.8	-6.15
		5091.12	-2.06	VALD	...	...	2.2	-6.07
	KX	4736.99	-2.78	VALD	...	...	17.7	-6.30
	KX	4742.16	-3.13	VALD	...	...	9.9	-6.20
	KX	4779.05	-1.93	VALD	...	...	6.0	-6.19
Mn I					log Mn/ $N_T = \dots$			$-6.56 \pm 0.14$
	2	4030.75	-0.07	MF	...	...	91.7	-7.02
		4033.06	-0.47	MF	...	...	87.8	-6.94
		4034.48	-0.62	MF	...	...	77.4	-6.64
	5	4018.10	0.29	BB	...	...	29.1	-6.70
		4041.55	0.29	MF	...	...	91.7	-7.02
		4048.74	-0.13	MF	...	...	64.7	-6.16
		4055.54	-0.59	BB	...	...	87.8	-6.94
		4058.93	-0.46	BB	...	...	18.7	-6.64
		4070.28	-1.04	BB	...	...	10.4	-6.34
		4079.28	-0.42	MF	...	...	21.7	-6.62
		4079.41	-0.42	MF	...	...	17.0	-6.71
		4082.93	-0.35	MF	...	...	24.4	-6.60
		4083.62	-0.25	MF	...	...	40.4	-6.41
	16	4754.08	-0.07	BB	...	...	34.8	-6.64
		4783.42	0.06	BB	...	...	42.5	-6.65
		4823.52	0.15	BB	...	...	48.8	-6.63
	17	6013.51	0.43	BB	...	...	11.2	-6.33
		6016.59	0.25	BB	...	...	12.9	-6.44
		6021.73	0.12	BB	...	...	14.4	-6.52
	21	4709.71	-0.49	BB	...	...	59.7	-6.71
		4739.08	-0.60	BB	...	...	7.3	-6.59
		4761.51	-0.14	BB	...	...	20.8	-6.64
		4762.36	0.43	BB	...	...	49.4	-6.34
		4765.84	-0.08	BB	...	...	13.5	-6.66
		4766.41	0.11	BB	...	...	21.5	-6.63
Mn II					log Mn/ $N_T = -6.78 \pm 0.14$			$-6.66 \pm 0.11$
	2	4205.38	-3.44	KG	8.3	-6.97	59.7	-6.71
	7	4244.25	-3.44	KG	...	...	7.3	-6.59
	5	4738.30	-1.88	KX	...	...	16.0	-6.49
	5	4755.73	-1.24	KX	17.5	-6.70	40.0	-6.60
		4764.73	-1.35	KX	18.6	-6.56	32.9	-6.62
	6	4326.64	-1.36	KS	16.3	-6.62	31.0	-6.64
		4343.98	-1.10	KS	14.4	-6.94	34.1	-6.84
	7	4206.37	-1.55	KS	6.5	-6.84	24.1	-6.58
		4252.96	-1.14	KX	5.5	-6.89	16.9	-6.65
	1	4251.74	-1.06	KX	9.2	-6.73	18.5	-6.68
	1	4791.78	-1.72	KX	...	...	2.9	-6.89
Fe I					log Fe/ $N_T = -4.59 \pm 0.20$			$-4.54 \pm 0.17$
	2	4375.93	-3.03	N4	...	...	70.3	-4.49
		4389.25	-4.58	N4	...	...	4.2	-4.47
		4427.31	-3.04	N4	...	...	63.6	-4.54
		4461.65	-3.21	N4	...	...	67.6	-4.29
	4	3878.57	-1.38	N4	36.7	-4.43	137.0	-4.56
		3886.28	-1.08	N4	...	...	142.7	-4.73
		3899.71	-1.53	N4	10.0	-4.93	123.7	-4.486
		3920.25	-1.75	N4	22.3	-4.31	107.3	-4.91
		3922.91	-1.65	N4	10.6	-4.81	134.3	-4.42
		3927.92	-1.52	N4	12.4	-4.83	119.6	-4.87
	15	5269.53	-1.32	N4	...	...	134.8	-4.38
		5328.03	-1.47	N4	...	...	129.5	-4.31
		5371.48	-1.65	N4	...	...	108.4	-4.52
		5397.12	-1.99	N4	...	...	84.5	-4.64
		5405.77	-1.84	N4	...	...	92.0	-4.61
		5429.69	-1.88	N4	...	...	96.4	-4.52
		5434.52	-2.12	N4	...	...	75.5	-4.58
		5446.91	-1.91	N4	...	...	85.4	-4.65
		5497.51	-2.85	N4	...	...	36.5	-4.45
		5455.60	-2.09	N4	...	...	70.7	-4.69
		5501.46	-3.05	N4	...	...	31.4	-4.38
		5506.77	-2.80	N4	...	...	40.5	-4.45
	16	4939.68	-3.34	VALD	...	...	19.2	-4.41
		4994.12	-3.08	N4	...	...	26.6	-4.46
		5012.06	-2.64	VALD	...	...	66.8	-4.32

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>	$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>
Fe I	(continued)							
	16	5041.07	-3.09	VALD	...	...	69.6	-4.70
		5051.63	-2.80	N4	...	...	44.1	-4.44
		5079.73	-3.22	N4	...	...	24.5	-4.31
	20	3840.44	-0.51	N4	24.7	-4.94	132.7	-4.87
	22	3850.82	-1.73	N4	5.4	-4.44	87.2	-4.65
	42	4147.63	-2.10	N4	...	...	46.0	-4.60
		4202.02	-0.71	N4	14.3	-4.74	...	...
	42	4250.79	-0.71	N4	14.5	-4.69	113.5	-4.71
		4271.76	-0.16	N4	31.8	-4.89	136.5	-5.05
		4307.90	-0.07	N4	...	...	138.8	-4.93
		4325.75	-0.01	N4	...	...	136.8	-4.99
	43	4005.25	-0.61	N4	11.4	-4.88	119.5	-4.555
		4063.60	+0.06	N4	40.6	-4.91	...	...
		4071.74	-0.02	N4	37.1	-4.85	141.3	-4.78
		4132.06	-0.67	N4	18.4	-4.57	106.6	-4.94
		4143.81	-0.51	N4	...	...	122.1	-4.81
	68	4408.42	-1.78	N4	...	...	45.8	-4.42
		4430.62	-1.66	N4	...	...	40.9	-4.60
		4442.34	-1.26	N4	...	...	68.2	-4.62
		4447.72	-1.34	N4	...	...	61.7	-4.61
		4459.12	-1.28	N4	...	...	88.5	-4.31
		4494.57	-1.14	N4	...	...	73.4	-4.67
		4528.61	-0.82	N4	...	...	90.0	-4.76
	71	4282.41	-0.78	N4	12.6	-4.30	91.9	-4.71
		4315.08	-0.97	N4	...	...	88.9	-4.56
		4352.74	-1.29	N4	...	...	55.4	-4.74
	72	3943.34	-2.34	N4	...	...	13.3	-4.50
		3949.95	-1.20	N4	...	...	63.5	-4.64
		3974.76	-2.61	N4	...	...	9.6	-4.40
		3977.40	-1.12	N4	...	...	78.1	-4.54
		4001.66	-1.90	N4	...	...	34.0	-4.46
		4009.71	-1.25	N4	...	...	60.7	-4.66
		4030.19	-2.31	N4	...	...	18.5	-4.37
	73	3852.73	-2.34	N4	...	...	56.6	-4.80
	115	4574.71	-2.89	N4	...	...	5.7	-4.34
		4630.12	-2.59	N4	...	...	10.8	-4.34
	116	4439.88	-3.00	N4	...	...	2.5	-4.59
	152	4187.04	-0.55	N4	...	...	96.7	-4.63
		4187.80	-0.55	N4	...	...	115.0	-4.28
		4191.43	-0.67	N4	...	...	101.7	-4.40
		4198.31	-0.72	N4	...	...	112.7	-4.18
		4210.35	-0.93	N4	...	...	89.9	-4.36
		4222.22	-0.97	N4	...	...	70.8	-4.65
		4233.60	-0.60	N4	...	...	97.2	-4.56
		4235.94	-0.34	N4	...	...	128.3	-4.21
		4250.12	-0.34	N4	...	...	102.2	-4.66
		4260.47	-0.08	N4	19.6	-4.83	128.4	-4.66
		4271.15	-0.35	N4	7.6	-4.83	107.8	-4.63
		4299.23	-0.41	N4	...	...	112.9	-4.49
	175	3859.21	-0.75	N4	5.2	-4.57	...	...
	278	3956.67	-0.43	N4	4.3	-4.81	71.5	-4.96
		3937.33	-1.46	N4	...	...	29.6	-4.59
		3997.39	-0.48	N4	8.8	-4.41	103.8	-4.29
		4021.87	-0.73	N4	6.8	-4.26	61.3	-4.77
	280	3897.90	-0.74	N4	...	...	63.7	-4.76
		3907.94	-1.12	N4	...	...	45.0	-4.61
	318	4871.32	-0.36	N4	...	...	98.3	-4.58
		4872.14	-0.57	N4	...	...	79.8	-4.65
		4890.76	-0.39	N4	...	...	94.6	-4.60
		4891.49	-0.11	N4	...	...	103.6	-4.74
		4918.99	-0.34	N4	...	...	85.8	-4.81
		4920.50	+0.07	N4	...	...	117.4	-4.68
		5006.12	-0.62	N4	...	...	74.7	-4.72
	350	4422.57	-1.12	N4	...	...	60.5	-4.38
		4443.19	-1.04	N4	...	...	48.4	-4.63
		4454.38	-1.04	N4	...	...	36.0	-4.76
		4466.55	-0.60	N4	...	...	77.6	-4.66
	354	4107.49	-0.88	N4	...	...	47.6	-4.78
		4156.80	-0.81	N4	...	...	68.8	-4.55
		4175.64	-0.83	N4	...	...	59.3	-4.66
		4181.75	-0.37	N4	...	...	92.6	-4.60
	355	4154.50	-0.69	N4	...	...	66.9	-4.69
		4184.89	-0.87	N4	...	...	61.9	-4.59
		4191.68	-1.49	N4	...	...	28.0	-4.50
		4203.98	-1.01	N4	...	...	67.1	-4.37
		4213.64	-1.25	N4	...	...	31.6	-4.68
	359	4062.44	-0.86	N4	...	...	...	...
	383	5068.76	-1.04	N4	...	...	46.1	-4.62
		5139.25	-0.51	N4	...	...	73.6	-4.68
		5191.45	-0.55	N4	...	...	69.6	-4.68
		5192.34	-0.42	N4	...	...	72.6	-4.79
		5226.86	-0.56	N4	...	...	86.2	-4.39
		5232.93	-0.06	N4	...	...	118.0	-4.37
		5266.55	-0.39	N4	...	...	74.9	-4.79
		5281.79	-0.83	N4	...	...	55.4	-4.62
	430	3918.64	-0.73	N4	...	...	55.7	-4.65

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>	$W_\lambda(\text{m\AA})$	log N/N <sub>T</sub>
Fe I	(continued)							
	522	4199.10	+0.16	N4	9.6	-4.84	94.5	-4.83
	528	3843.26	-0.24	N4	4.8	-4.72	71.0	-4.819
	664	3846.80	-0.02	N4	4.5	-4.85	71.7	-4.88
		3906.75	-0.95	N4	...	...	30.5	-4.62
	686	5615.64	0.05	N4	...	...	103.0	-4.488
		5569.61	-0.49	N4	...	...	57.2	-4.648
		5572.84	-0.28	N4	...	...	65.9	-4.741
	686	5576.09	-0.94	N4	...	...	40.1	-4.46
		5586.75	-0.14	N4	...	...	85.8	-4.58
		5602.94	-0.85	N4	...	...	38.6	-4.57
		5624.54	-0.76	N4	...	...	41.7	-4.62
		5658.53	-1.86	N4	...	...	17.3	-4.02
		5658.81	-0.84	N4	...	...	33.6	-4.70
		5709.37	-1.03	N4	...	...	31.6	-4.57
		5712.13	-1.99	N4	...	...	4.7	-4.52
	693	4195.22	-0.49	VALD	...	...	60.4	-4.62
		4217.54	-0.48	N4	...	...	53.5	-4.66
		4225.45	-0.51	N4	...	...	60.0	-4.55
		4227.43	0.27	N4	...	...	105.2	-4.63
		4238.82	-0.23	N4	...	...	83.6	-4.48
		4247.42	-0.24	N4	...	...	82.8	-4.51
	695	4114.93	-1.45	N4	...	...	12.0	-4.59
		4126.18	-0.92	N4	...	...	38.3	-4.52
		4150.25	-0.32	N4	...	...	21.0	-4.53
		4153.91	-0.32	N4	...	...	66.0	-4.66
		4157.78	-0.40	N4	...	...	55.5	-4.72
		4158.80	-0.70	N4	...	...	42.0	-4.61
		4176.57	-0.81	VALD	...	...	54.1	-4.37
	801	4118.55	+0.22	N4	8.1	-4.65	84.5	-4.76
	828	4401.29	-0.89	N4	...	...	32.5	-4.48
		4484.21	-0.86	N4	...	...	37.1	-4.43
	1062	5473.90	-0.79	N4	...	...	21.9	-4.43
		5476.56	-0.45	N4	...	...	51.9	-4.28
		5563.59	-0.96	N4	...	...	18.2	-4.33
	1065	4991.26	-0.67	FW	...	...	29.1	-4.36
	1145	5389.47	-0.41	VALD	...	...	28.4	-4.47
		5398.27	-0.71	N4	...	...	19.6	-4.35
		5400.50	-0.16	FW	...	...	46.9	-4.44
		5455.44	0.33	VALD	...	...	61.5	-4.76
		5461.55	-1.88	N4	...	...	2.8	-4.09
		5546.50	-1.28	N4	...	...	7.7	-4.29
	1146	5364.85	0.23	N4	...	...	55.6	-4.65
		5367.47	0.44	N4	...	...	64.1	-4.76
		5369.95	0.35	N4	...	...	68.7	-4.63
		5383.36	0.65	N4	...	...	82.3	-4.77
		5393.16	-0.91	N4	...	...	45.8	-4.55
		5424.06	0.52	N4	...	...	89.3	-4.53
	1162	5412.80	-1.72	FW	...	...	3.0	-4.23
	1163	5349.73	-1.28	N4	...	...	11.6	-4.09
		5445.04	-0.02	FW	...	...	44.3	-4.58
		5462.95	-0.23	FW	...	...	41.3	-4.45
		5463.27	0.07	N4	...	...	49.1	-4.59
		5562.70	-0.66	FW	...	...	12.8	-4.63
Fe II					log Fe/N <sub>T</sub> = -4.61±0.18			-4.62±0.17
	21	4177.69	-3.45	VALD	...	...	108.5	-4.21
		4183.20	-5.09	VALD	4.6	-4.48	16.8	-4.70
	22	4124.79	-4.16	N4	...	...	55.1	-4.74
	25	4634.61	-5.53	VALD	...	...	7.6	-4.67
		4648.94	-4.57	VALD	8.1	-4.79	37.9	-4.79
		4670.18	-4.07	N4	20.3	-4.86	68.4	-4.65
	26	4386.57	-5.15	VALD	...	...	20.7	-4.57
		4461.43	-4.37	VALD	46.4	-4.12	64.8	-4.65
		4580.06	-3.73	VALD	35.6	-4.91	73.5	-4.77
	27	4128.74	-3.58	N4	66.8	-4.66	...	...
		4173.46	-2.16	N4	181.1	-4.85	...	...
		4233.17	-1.81	N4	...	...278.5	-4.17	...
		4416.83	-2.60	N4	...	...	...	...
		4665.80	-5.00	VALD	9.2	-4.23	12.6	-4.77
	28	4087.27	-4.52	N4	9.3	-4.76	32.2	-4.72
		4122.66	-3.30	N4	88.8	-4.72	...	...
		4258.16	-3.48	N4	75.2	-4.61	86.4	-4.81
		4369.40	-3.58	N4	48.4	-4.76	82.4	-4.74
	29	3908.54	-5.08	VALD	6.5	-4.28	11.4	-4.89
		3964.57	-4.69	VALD	...	...	48.6	-4.88
		3974.16	-4.05	N4	43.7	-4.38	73.5	-4.42
	30	4833.19	-4.79	N4	8.0	-4.49	31.6	-4.42
		4839.99	-4.95	N4	3.5	-4.89	23.9	-4.44
	32	4278.15	-3.95	VALD	40.1	-4.55	93.1	-4.43
		4296.57	-2.93	VALD	...	...	121.5	-4.79
		4314.31	-3.60	VALD	80.1	-4.58	118.4	-4.20
		4384.33	-3.68	N4	...	...	109.0	-4.23
		4413.60	-4.19	N4	...	...	57.4	-4.60

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log $N/N_T$	$W_\lambda(\text{m\AA})$	log $N/N_T$
Fe II	( <i>continued</i> )							
	32	4439.13	-5.50	VALD	...	...	6.2	-4.50
	36	4993.35	-3.68	N4	38.5	-4.78	...	...
	37	4472.92	-3.53	N4	58.3	-4.66	82.1	-4.75
		4489.18	-2.97	N4	122.8	-4.58	...	...
		4491.40	-2.64	N4	152.0	-4.58	...	...
		4515.34	-2.36	N4	...	...	167.8	-4.21
		4520.23	-2.62	N4	109.3	-5.15	148.1	-4.43
	37	4555.89	-2.25	N4	...	...	156.3	-4.65
		4582.84	-3.06	N4	98.2	-4.72	107.1	-4.78
		4629.34	-2.26	N4	182.6	-4.65	157.6	-4.65
		4666.76	-3.33	N4	...	...	9.88	-4.69
	38	4508.28	-2.35	N4	...	...	173.9	-4.31
		4522.63	-1.99	N4	220.1	-4.45	161.8	-4.85
		4541.52	-2.97	N4	110.5	-4.69	121.9	-4.58
		4576.33	-2.92	N4	110.6	-4.74	118.7	-4.71
		4583.83	-1.74	N4	220.4	-4.73	...	...
		4595.68	-4.58	VALD	4.8	-4.85	28.6	-4.89
		4620.51	-3.19	N4	...	...	105.7	-4.61
	39	4088.76	-4.68	VALD	4.3	-4.79	20.0	-4.51
		4138.40	-4.32	VALD	...	...	42.3	-4.42
	41	5256.93	-4.18	VALD	...	...	52.3	-4.65
		5284.10	-3.20	N4	...	...	111.5	-4.67
	43	4656.97	-3.57	N4	48.4	-4.71	90.7	-4.56
		4731.44	-3.13	N4	76.3	-4.85	112.6	-4.60
	44	4663.70	-3.89	VALD	...	...	66.9	-4.65
	48	5264.81	-3.32	N4	...	...	97.2	-4.52
		5316.78	-2.78	N4	...	...	148.5	-4.21
		5362.87	-2.62	VALD	...	...	158.3	-4.30
		5414.07	-3.65	VALD	...	...	62.9	-4.73
	49	5197.57	-2.05	N4	187.9	-4.63	177.9	-4.43
		5234.62	-2.21	N4	...	...	155.3	-4.62
		5276.00	-1.90	N4	...	...	189.9	-4.46
		5316.61	-1.85	N4	...	...	173.7	-4.77
		5425.25	-3.39	N4	...	...	9.18	-4.56
	126	4032.94	-2.57	VALD	47.0	-4.79	68.5	-4.56
		4046.81	-4.37	VALD	...	...	7.4	-4.53
	127	4024.55	-2.44	N4	90.3	-4.43	76.0	-4.69
	141	4147.27	-3.79	VALD	5.3	-4.58	...	...
	150	4138.21	-3.47	VALD	15.2	-4.35	21.6	-4.76
	151	4031.41	-3.16	VALD	...	...	28.1	-4.67
	152	3863.38	-3.51	VALD	20.9	-4.15	...	...
	153	3827.08	-2.36	N4	67.7	-4.61	...	...
	167	5127.86	-2.45	VALD	...	...	33.6	-4.55
		5160.83	-2.56	VALD	...	...	33.9	-4.44
	169	4760.15	-3.64	VALD	...	...	2.9	-4.76
		4810.74	-3.29	VALD	...	...	8.4	-4.60
	171	4474.19	-3.37	VALD	7.1	-4.33	9.7	-4.63
	172	4041.64	-3.38	VALD	5.1	-4.48	16.0	-4.39
		4044.01	-2.67	VALD	21.1	-4.52	...	...
		4048.83	-2.38	VALD	41.5	-4.45	...	...
	173	3906.04	-1.70	N4	81.9	-4.64	...	...
	186	4625.91	-2.55	VALD	15.0	-4.59	...	...
		4635.33	-1.58	N4	70.3	-4.66	...	...
	187	4446.25	-2.78	VALD	7.2	-4.70	12.1	-4.96
	188	4111.90	-2.67	VALD	13.3	-4.54	...	...
	190	3938.97	-1.93	N4	55.7	-4.52	...	...
	205	5074.05	-2.17	VALD	...	...	9.1	-4.96
	212	3960.90	-1.56	VALD	28.4	-4.56	...	...
	213	4354.34	-1.35	VALD	15.8	-4.85	24.2	-4.51
		4507.10	-1.76	VALD	7.9	-4.63	...	...
	219	4598.53	-1.54	VALD	13.1	-4.65	...	...
		4625.55	-2.13	VALD	3.7	-4.60	...	...
		4318.19	-1.88	VALD	...	...	5.7	-4.59
		4319.68	-1.64	VALD	16.8	-4.43	10.4	-4.56
		4321.31	-1.74	VALD	11.0	-4.52	7.3	-4.65
	221	5081.90	-1.06	VALD	...	...	2.0	-4.75
	222	4431.64	-1.79	VALD	...	...	8.2	-4.52
		4449.66	-1.70	VALD	6.2	-4.89	10.5	-4.59
	D	3844.79	-1.02	VALD	8.3	-4.77	...	...
		3894.63	-2.08	VALD	4.0	-4.82	13.1	-4.27
		3898.62	-1.71	VALD	12.8	-4.66	13.1	-4.65
		3922.04	-1.07	VALD	5.5	-4.87	5.9	-4.97
		3926.68	-2.50	VALD	...	...	5.5	-4.28
		4202.52	-2.36	VALD	11.2	-4.46	8.0	-4.69
		4319.42	-1.99	VALD	...	...	6.5	-4.48
		4384.08	-2.58	VALD	...	...	21.6	-4.34
		4418.98	-1.85	VALD	...	...	7.1	-4.51
		4467.97	-2.50	VALD	...	...	3.3	-4.37
		4487.50	-2.14	VALD	...	...	6.5	-4.41
		4563.15	-2.39	VALD	...	...	2.2	-4.45
	G	3924.83	-1.10	VALD	...	...	2.3	-4.84
		4213.52	-1.84	VALD	...	...	8.9	-4.18
		4377.34	-2.93	VALD	...	...	3.2	-4.53
	J	4263.87	-1.69	VALD	17.5	-4.44	17.3	-4.40
		4357.58	-2.01	VALD	39.7	-4.55	33.8	-4.74
		4361.25	-2.26	VALD	17.2	-4.72	...	...
		4402.87	-2.56	VALD	...	...	23.2	-4.38

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	$\log N/N_T$	$W_\lambda(\text{m\AA})$	$\log N/N_T$
Fe II	(continued) J	4451.55	-1.91	VALD	...	...	57.1	-4.42
		4455.27	-2.00	VALD	...	...	43.4	-4.49
		4480.68	-2.56	VALD	...	...	19.6	-4.41
		4579.53	-2.34	VALD	22.5	-4.45	...	...
		4640.84	-1.74	VALD	6.7	-4.82	...	...
		4820.85	-0.72	VALD	7.0	-4.46	...	...
		4824.84	-2.17	VALD	4.8	-4.57	2.2	-4.55
		4836.95	-2.24	VALD	...	...	4.5	-4.14
		4843.21	-2.48	VALD	6.3	-4.48	6.3	-4.13
		4845.36	-2.38	VALD	3.9	-4.44	...	...
		4883.28	-0.60	VALD	10.7	-4.36	2.9	-4.68
		4893.82	-4.27	N4	9.4	-4.87	43.2	-4.48
		4908.15	-0.27	VALD	9.9	-4.70	5.7	-4.65
		4913.29	+0.05	VALD	20.9	4.66	8.9	-4.77
		4948.10	-0.22	VALD	...	...	4.8	-4.79
		4948.79	-0.03	VALD	...	...	7.4	-4.74
		4951.58	+0.21	VALD	...	...	12.0	-4.53
		4984.49	+0.01	VALD	20.4	-4.60	9.2	-4.67
		4990.50	+0.20	VALD	...	...	9.9	-4.82
		4999.18	-0.44	VALD	7.7	-4.67	5.8	-4.49
		5000.74	-4.58	VALD	7.0	-4.73	33.8	-4.56
		5021.59	-0.30	VALD	20.3	-4.31	11.8	-4.36
		5022.42	-0.06	VALD	9.8	-4.89	7.9	-4.66
		5022.79	-0.07	VALD	28.1	-4.36	9.5	-4.64
		5026.80	-0.44	VALD	14.4	-4.34	5.6	-4.48
		5030.63	+0.43	VALD	39.5	-4.64	19.4	-4.64
		5032.71	+0.08	VALD	...	...	11.1	-4.59
		5035.70	+0.63	VALD	56.4	-4.56	24.4	-4.74
		5070.90	+0.27	VALD	...	...	10.7	-4.84
		5082.23	-0.13	VALD	13.8	-4.61	5.9	-4.71
		5089.21	0.01	VALD	11.8	-4.87	6.6	-4.82
		5093.56	0.16	VALD	33.5	-4.42	9.3	-4.76
		5097.27	0.32	VALD	36.9	-4.51	13.2	-4.73
		5112.99	-0.53	VALD	4.4	-4.76	1.5	-4.93
		5115.06	-0.50	VALD	3.5	-4.92	3.1	-4.60
		5117.01	-0.04	VALD	9.3	-4.88	5.8	-4.76
		5119.34	-0.67	VALD	2.5	-4.87	2.0	-4.66
		5120.35	-4.26	VALD	...	...	44.2	-4.67
		5132.66	-4.09	N4	17.0	-4.79	60.8	-4.62
		5143.88	-0.20	VALD	10.6	-4.65	3.7	-4.80
		5144.36	+0.31	N4	25.6	-4.68	11.6	-4.72
		5150.49	-0.08	VALD	12.6	-4.68	4.5	-4.83
		5154.43	-4.27	VALD	...	...	47.5	-4.60
		5157.28	-0.17	VALD	13.7	-4.54	6.4	-4.56
		5166.56	-0.05	VALD	19.1	-4.49	4.2	-4.88
		5170.78	-0.33	VALD	12.3	-4.44	...	...
		5180.31	-0.09	VALD	17.5	-4.53	17.5	-4.13
		5199.12	+0.12	VALD	18.1	-4.72	8.1	-4.77
		5203.64	-0.12	VALD	...	...	7.3	-4.57
		5246.81	-3.13	VALD	72.0	-4.68	...	...
		5337.73	-3.79	VALD	35.0	-4.47	...	...
		5362.86	-2.62	VALD	156.8	-4.36	...	...
Fe III				$\log \text{Fe}/N_T = -4.69\pm0.06$		...		
	4	4419.60	-2.22	KX	11.6	-4.68	...	...
	5	5127.38	-2.57	KX	5.9	-4.63	...	...
	9	5156.11	-2.02	KX	6.5	-4.77	...	...
Co I				...		$-7.17\pm0.15$		
	18	3873.11	-0.66	FW	...	...	37.6	-7.04
		3873.95	-0.97	FW	...	...	26.7	-6.97
		3894.07	0.10	FW	...	...	59.9	-6.99
	29	4092.38	-0.34	FW	...	...	6.1	-7.35
		4110.53	-1.08	KX	...	...	12.5	-7.19
	34	3845.38	0.01	FW	...	...	38.7	-7.32
		3894.97	-1.40	FW	...	...	3.7	-7.31
Co II				$\log \text{Co}/N_T = -7.16$		$-6.95\pm0.20$		
	1	3578.01	-1.91	KX	...	...	25.0	-7.06
	2	3415.77	-1.74	FW	...	...	45.6	-6.76
		3423.83	-1.68	KX	...	...	29.6	-7.16
		3446.38	-1.33	KX	...	...	26.4	-7.11
		3501.71	-1.18	KX	24.9	-7.16	71.1	-6.68
Ni I				$\log \text{Ni}/N_T = \dots$		$-5.73\pm0.12$		
	86	4401.53	+0.08	FW	...	...	50.1	-5.84
		4462.44	-0.60	FW	...	...	11.1	-5.81
		4470.47	-0.40	FW	...	...	18.4	-5.81
	98	4592.52	-0.36	FW	...	...	16.9	-5.79
		4600.35	-0.61	FW	...	...	15.3	-5.55
		4604.98	-0.29	FW	...	...	22.7	-5.76
		4648.64	-0.16	FW	...	...	27.5	-5.83
		4714.40	0.23	FW	...	...	47.5	-5.91
		4756.51	-0.34	FW	...	...	19.4	-5.80
		4786.53	-0.17	FW	...	...	44.9	-5.52

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/ $N_T$	$W_\lambda(\text{m\AA})$	log N/ $N_T$
Ni I	(continued)	3908.91	-0.57	KX	...	...	10.1	-5.73
		117						
		4855.40	0.00	FW	...	...	25.7	-5.95
		130						
		4829.01	-0.33	FW	...	...	21.6	-5.71
		131						
		4752.43	-0.70	FW	...	...	9.1	-5.68
Ni II		4913.96	-0.63	FW	...	...	9.6	-5.65
		163						
		4806.97	-0.64	FW	...	...	12.9	-5.57
		163						
		4546.92	-0.27	KX	...	...	13.1	-5.55
Ni II								
Zn I								
Sr II								
Y II								
Zr II								
Ba II								
La II								
Ce II								

Table A1: - *continued*

Species	Multiplet	$\lambda(\text{\AA})$	log gf	Ref.	HD 80057		HD 80404	
					$W_\lambda(\text{m\AA})$	log N/ $N_T$	$W_\lambda(\text{m\AA})$	log N/ $N_T$
Eu II	1	3819.67	+0.51	LW	log Eu/ $N_T$ = ...			-11.74±0.13
		4129.70	+0.22	LW	...	...	24.7	-11.82
		4205.05	+0.21	LW	...	...	18.7	-11.72
	5				...	...	26.3	-11.54
		3907.10	+0.17	LW	...	...	8.2	-11.88

Note: gf value references follow:

AT = Aldenius et al. (2007); B= Brage et al. (1998) BB= Blackwell-Whitehead & Bergemann (2007);  
 BG = Biemont et al. (1981), Biemont et al. (1989); CB = Corliss & Bozman (1962); CR = Wiese & Fuhr (2007)  
 DS = Davidson et al. (1992) FW = Fuhr & Wiese (2002) and Fuhr et al. (1988); HL = Hannaford et al. (1982)  
 JK = Jönsson et al. (1984) KG = Kling & Griesmann (2000); KS = Kling et al. (2001); KX = Kurucz (1995)  
 LA = Lanz & Artru (1985); LB = Lawler et al. (2001) LD = Lawler & Dakin (1989); LN = Ljung et al. (2006)  
 LW = Lawler et al. (2001); MC = Meggers et al. (1975) NL = Nilsson et al. (2006)  
 N4 = Fuhr & Wiese (2006); MF = Fuhr et al. (1988) and Martin et al. (1988); RP = Raassen et al. (1998)  
 PT = Pickering et al. (2001); Pickering et al. (2002); PQ= Palmeri et al. (2000); SG = Schulz-Gulde (1969)  
 WF = Wiese et al. (1996); WM = Wiese & Martin (1980); WS = Wiese et al. (1969);  
 VALD, VALD2 data= Piskunov et al. (1995), Ryabchikova et al. (1997), Kupka et al. (1999)  
 Kupka et al. (2000)